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A case study in bulk warehouse modernization at the Naval Supply Center, Oakland, California.

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A CASE STUDY IN BULK WAREHOUSE MODERNIZATION AT THE NAVAL SUPPLY CENTER OAKLAND, CALIFORNIA

Richard Daniel Robinson

NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

A CASE STUDY IN BULK WAREHOUSE MODERNIZATION
AT THE NAVAL SUPPLY CENTER
OAKLAND, CALIFORNIA

by

Richard Daniel Robinson

June 1977

Thesis Advisor: S. M. DEAN

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AT THE NAVAL SUPPLY CENTER
OAKLAND, CALIFORNIA

by

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Submitted in partial fulfillment of the
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I. PREFACE

As a result of World War II, the United States Navy has become a world-wide organization with many functional areas working together to achieve the Navy's mission of freedom of the sea lanes. One of the functional areas, the supply system, has been tasked with providing a large amount of the logistics support required to sustain the ships and stations in the performance of their missions.

Since World War II, much has been done to improve the responsiveness and effectiveness of the Navy Supply System by mechanizing or automating many of the functions. Until the early part of the 1960's, most of the improvements were in the documentation and record keeping elements of the supply system. The application of automated data processing and faster, improved communications to many of the inventory management functions were representative of these improvements.

In the early 1960's mechanization was introduced into the Navy warehouse operation with installation of automated materials handling systems at the major Supply Centers. The target of this mechanization was the sixty-nine percent of Navy items stored in binnable locations that accounted for sixty-four percent of the issues (though not necessarily a corresponding manpower investment).[1] These systems proved their worth during

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[1] DOD Depot Storage Facility Modernization Phase II Final Report Task Group 5-70 of the Logistics Systems Policy Committee, pg. 2.

the Vietnam war era when the Supply System was placed under the heaviest strain in two decades.

One of the remaining frontiers in mechanization in the Navy Supply System is in the handling of non-binnable materials -- those materials stored in bulk and rack locations. These items, though representing less than a third of the line items carried, and slightly over a fourth of the issues, are currently consuming manpower and material handling equipment (MHE) in a disproportionate manner when compared to binnable items. With increasing labor rates, reduced manning levels, rising operating and maintenance costs for MHE, and reduced responsiveness to customer demands for non-binnable items, the feasibility of applying some form of mechanization or automation to this type of material has come under increased investigation.

The Naval Supply Center Oakland, the largest West Coast stock point, has been chosen as the setting for a case study in the modernization of handling of non-binnable materials in Navy warehouses. The case is intended to provide a study medium in the area of warehouse modernization for courses in the material management curriculum at service or civilian educational institutions. An apparent shortcoming of the management training in this area was highlighted by a recent management consultant stating that "one of the disturbing aspects of the warehouse modernization study concerned the

lack of general understanding of both the importance of effective materials management and the overall operation of the Supply Center among the members of the management at the Supply Center."[2]

An analysis of non-binnable material stored in general purpose warehouses at NSC Oakland was conducted to determine the characteristics of the material and hence, the types of modernization that would be best suited to the material in question. The information gathered from this analysis was used in conjunction with a draft copy of the Naval Supply Systems Command Publication 529, Warehouse Modernization and Layout Planning Guide, to determine the alternatives that would be feasible for improving the handling of non-binnable material. The final step was to perform an economic analysis of the alternatives in accordance with the Naval Supply Systems Command Instruction 7000.10A, Economic Analysis and Program Evaluation for Resource Management. The results of this analysis and the recommendations are the basis for the teaching note to the case as well as a recommended solution to NSC Oakland's quest to modernize the handling of non-binnable material.

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[2]NSC Oakland Warehouse Modernization Report, 8 May 1975, Roach Systems Division of Roach Mfr. Co., pg. 4-20.

II. INTRODUCTION

Ted Toklas, the bulk storage branch supervisor, returned to his office after the retirement party for James Brown, one of the warehousemen in Unit C. As he shuffled through the papers from his in-basket, he came across the recently promulgated executive order which decreed that only 75% of vacancies could be filled under the new hiring freeze. In the past few years, a diminishing workforce had become a way of life, as the Naval Supply Center Oakland absorbed its share of personnel cuts under the Department of Defense Reduction-in-Force programs. "That will keep Unit C undermanned for a while," he muttered. As he glanced at his calendar, he noticed that tomorrow was the day for handing out thirty-year pins. Ted felt sure that several of the warehousemen from his branch would be included in that group. He recalled the Naval Supply Systems Command Report published in 1973 that highlighted the fact that 61% of NSC Oakland's warehousemen were eligible to retire by 1983 and that 93% of senior warehousemen grades 6 through 9 would be eligible to retire in that same time frame.[1] Ted speculated that if Civil Service pay was not so good, many of the warehousemen eligible to retire would have done so. Wage grade 5 warehousemen earned $7.34/hour and wage grade 6 warehousemen earned $7.69/hour.[2]

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[1] NAVSUP "Retirement Eligibility as of June 73-83," Report dated 15 June 1973.

[2] Federal Wage System Regular and Special Production Facilitating Wage Rate Schedules for the Wage Area of San Francisco, California, dated 3 November 1976. Note--when computing cost of labor, a 38% allowance of base wage rate is added to the above for leave and fringe benefits.

Ted's thoughts shifted from personnel to productivity as the daily work reports hit his desk. Glancing over the reports, he could see that the operation had not changed much since yesterday. He made the usual calculations and was not surprised by the statistic of four issues per man hour that appeared. Backlogs in issues and disposals were up slightly over the previous day's figures. The trends in these two areas were becoming a cause for concern for Ted, as he watched the operation slip slowly behind what he considered a current state of readiness.

Working his way down through the pile of paperwork, he came across a memo from Commander Sechler, the Material Division head, requesting suggestions for productivity enhancing projects that could show a payback of two years or less. Ted began to do some serious reminiscing about all of the material handling improvements and innovations he had seen in other installations and establishments during his career in material management, which spanned thirty years. His thoughts latched onto previous recommendations and submissions to the Naval Supply Systems Command for improvements in the handling of non-binnable items in the bulk storage warehouses. He decided that a review of these proposals in light of the current state-of-the-art technology recently observed in civilian installations would be a good starting point for preparation of a reply to the Commander's memorandum.

III. BACKGROUND

The Naval Supply Center Oakland was the largest West Coast stock point, with a supply and support role for all Naval forces in the Pacific, both fleet units and shore activities. In addition, NSC Oakland provided supply and support for Army, Air Force and Marine Corps stations on the West Coast, Coast Guard, Military Sealift Command and foreign Naval vessels in San Francisco Bay, and other governments through Foreign Military Sales and Military Assistance Programs. NSC Oakland also provided support and property management for a Navy base with more than forty tenant activities.

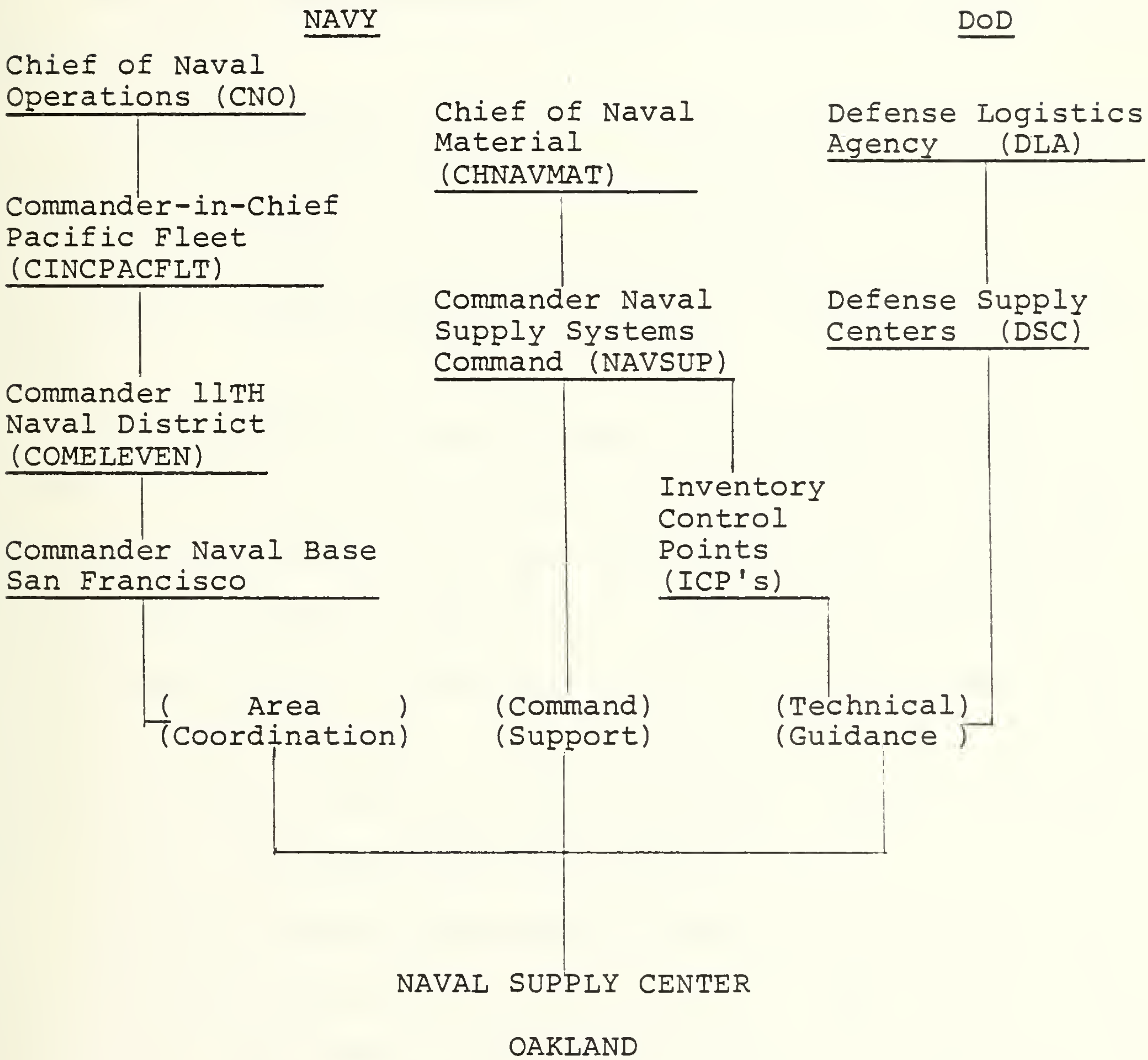
Exhibit 1 shows the relationship of NSC Oakland to other commands in the Navy and the Department of Defense. NSC Oakland served as a distribution point for material that was centrally managed by the Navy Inventory Control Points and Inventory Managers, as a specialized support depot for material that was centrally managed by Defense Supply Centers in the Defense Logistics Agency, and as a field warehouse for material managed by the General Services Administration. For a more detailed explanation of how the Naval Supply Center Oakland was integrated into the National Supply System, see Appendix A.

NSC Oakland performed all of the functions of supply management including requirements determination for locally managed items, cataloging, screening and identification, local procurement, inspection and acceptance, receiving, storage,

EXHIBIT 1.

Relationship of NSC Oakland to

Other Commands in the Navy and DoD



issuing, quality control, packing, preservation, and shipping. In order to perform these functions in an integrated manner, NSC Oakland was organized functionally as shown in Exhibit 2.

The center was commanded by a Rear Admiral, Supply Corps, and had an on-board strength of 1,852 personnel as of 1 November 1976.[1]

The Supply Center consisted of three sites -- the main site located in the port terminal area of Oakland, the fuel department at Pt. Molate, 16 miles north of the main site and the provisions storage facility at Alameda, a few miles from the main site.

The main site was established on 15 December 1941 and consisted of 78 buildings covering 532 acres. There were seven million square feet of covered storage area and 2.1 million square feet of open storage space. A 27 mile network of railroad tracks provided marshalling yards and rail access to both sides of each warehouse. Exhibit 3A is a map of the main site, showing building locations and facilities. Exhibit 3B shows the current use of the main buildings.

The center served approximately 4000 customers with one, Diego Garcia, being 11,000 miles distant. Approximately 592,000 individual line items of stock worth over $1 billion were carried to provide customer support. These items represented over 85

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[1]NSC Oakland command presentation dated 1 March 1977.

EXHIBIT 2.

Organization Chart of NSC Oakland

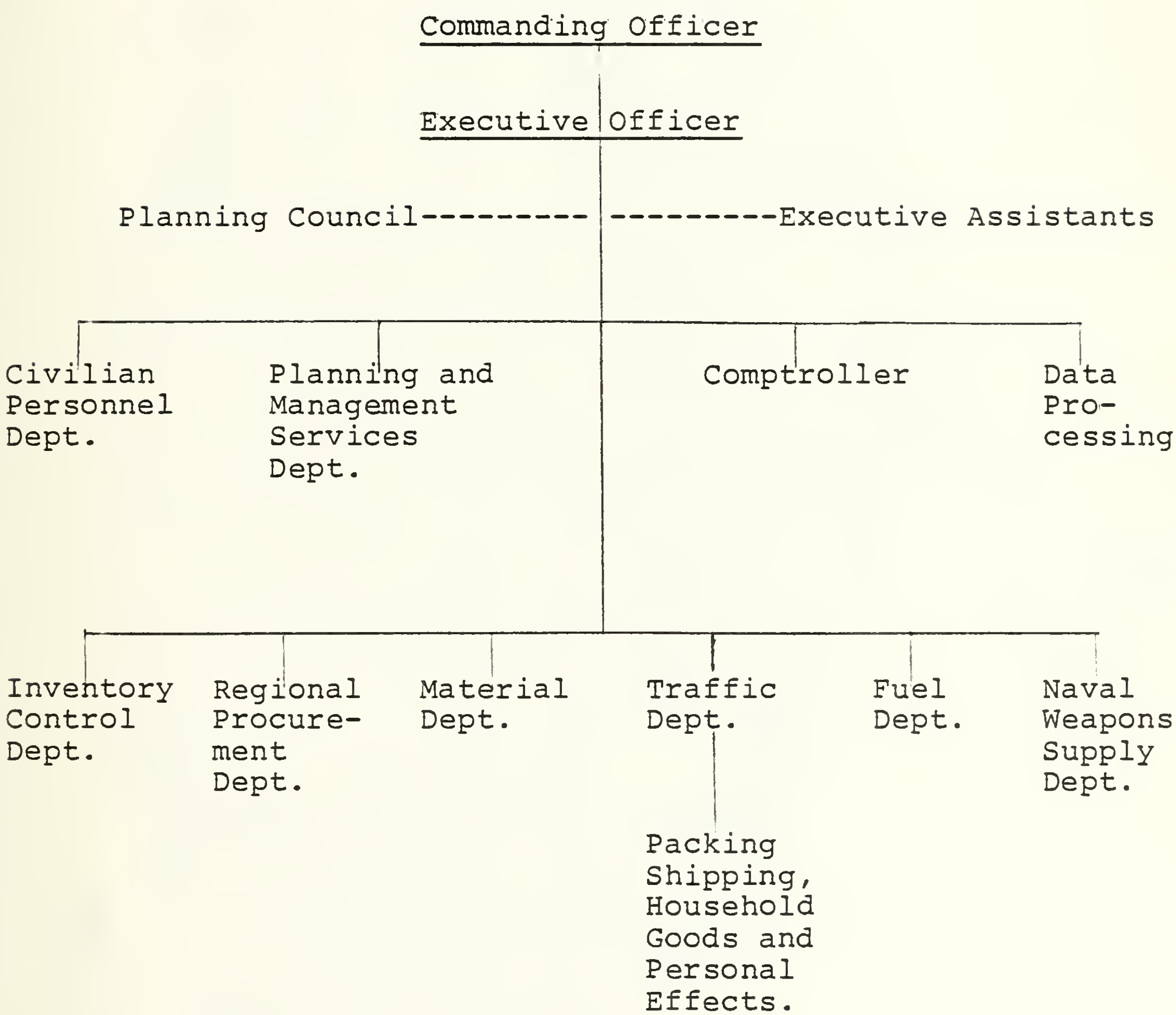

EXHIBIT 3A

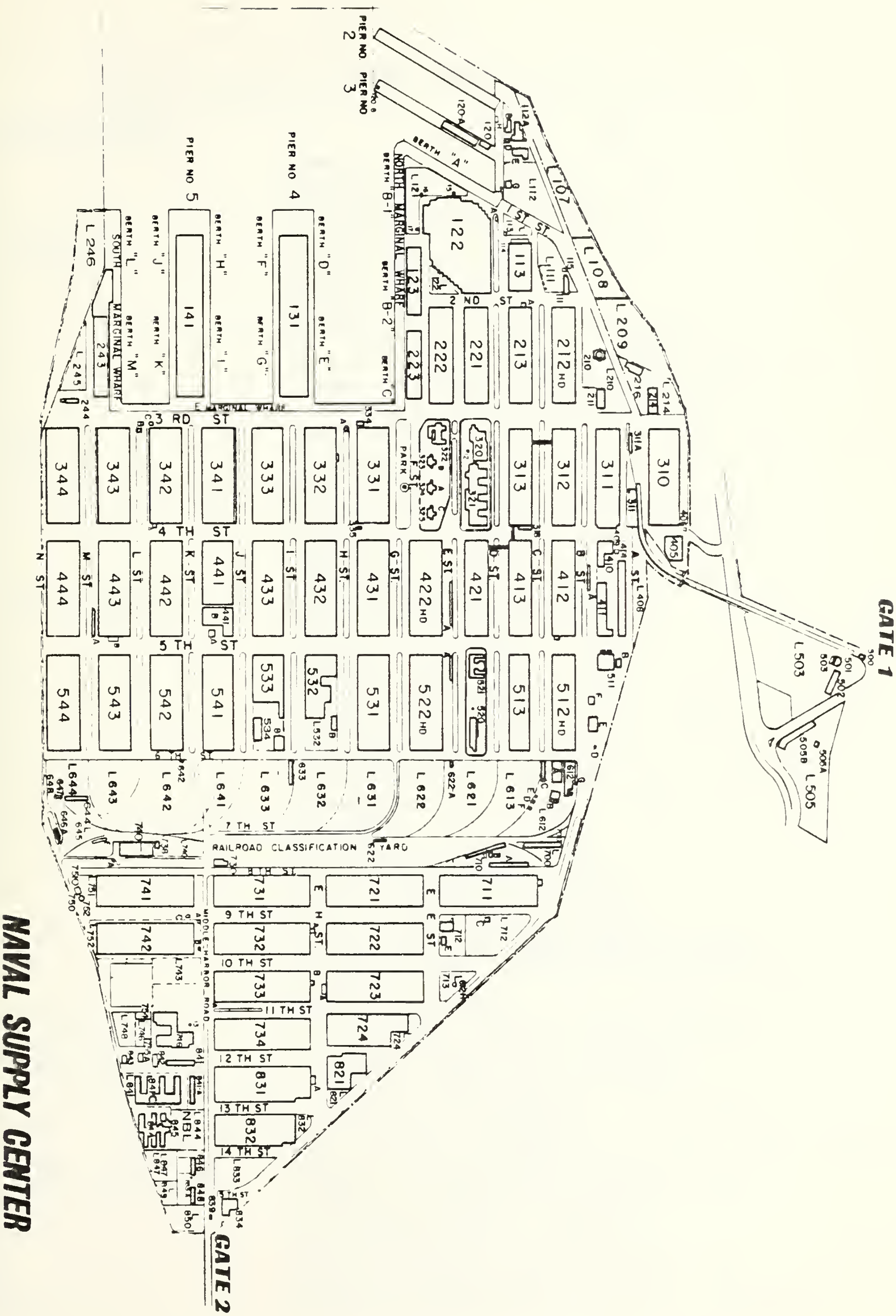
NAVAL SUPPLY CENTER
OAKLAND
GATE 1
GATE 2
PIER NO 2
PIER NO 3
PIER NO 4
PIER NO 5
BERTH "A"
BERTH "B-1"
BERTH "B-2"
BERTH "C"
BERTH "D"
BERTH "E"
BERTH "F"
BERTH "G"
BERTH "H"
BERTH "I"
BERTH "J"
BERTH "K"
BERTH "L"
BERTH "M"
NORTH MARGINAL WHARF
SOUTH MARGINAL WHARF
E MARGINAL WHARF
2 ND ST
3 RD ST
4 TH ST
5 TH ST
7 TH ST
8 TH ST
9 TH ST
10 TH ST
11 TH ST
12 TH ST
13 TH ST
14 TH ST
A ST
B ST
C ST
D ST
E ST
G ST
H ST
I ST
J ST
K ST
L ST
M ST
N ST
PARK
RAILROAD CLASSIFICATION YARD
MIDDLE HARBOR ROAD
NBL

Exhibit 3B.

MAIN BUILDINGS OF NSC OAKLAND AND THEIR USE

Building Number	Use
113	Small arms storage
122	Cable, motor parts storage
123	Assigned to ship's use
131 (Pier 4)	Large motors, slow moving
141 (Pier 5)	Large bulk items
212	Bulk receiving
213	Outfitting of ships
214	Radioactive material storage
221	Forms storage, Barber Shop, Post Office
222	Forms storage, NMTO, HHG office
310	MSCPAC HQ/Classified Storage
311	Data Processing/Inv Control/Acctg.
312/313	Bin storage
321	HQ bldg. - office space
331	Public Works Center, MHE storage
332	Shipping - Land/Van
333	Shipping - Land
341	Local Delivery/Air Shipping
342/343/344/443	Fast-Moving bulk storage
410	Security Storage
412	Pilferable items storage
413	MTIS receiving
421	Small pkg. receiving/Bin back-up storage
422	Boats, large bulk
431	Hazardous item storage
432	NRSO van stuffing, overseas exchange
433	Shipping
441	BAYMART
442	Sonobuoy storage
444	NRFI repairable storage
512	Small steel item storage
513	Large steel item storage
520	Transportation Management School
522	Boiler tubes, Nuclear Submarine piping
531	Lumber storage
532, 533, 541	Public Work Center Shops/Storage
542, 543, 544	RFI/NRFI repairable storage
Lots 600 blocks	Outside large bulk storage (steel, gun barrels, propellers)
700/700 lot/712/713/lot	Bottled gas storage
711	Paint/small packaged oil/lubricants storage
721/723	Regional Commissary complex
722/724/731/732	Large, slow-moving bulk storage
733	NAVELEX material storage
734	Clothing/textile storage
741	Large,slow-moving bulk storage
742	Nuclear Weapons Department
821	Nuclear Submarine spares
831,832	NAVSEA Electronics/machinery spares

major categories of material covering a range from aviation support to common hardware. The center averaged 115,500 issues and 22,566 receipts per month in fiscal year 1976. This represented more than 35,000 measurement tons in and out of the center each month, but was 10% less than the fiscal year 1975 average. Table 1. is an extract of workload figures for the last ten years.

A. THE MATERIAL DEPARTMENT

The material department was responsible for planning and directing the storage, maintenance-in-the-storage, issue and disposal operations of the supply center. The department head was a senior Supply Corps Commander who was assisted by a GS-13 deputy. The organization of the material department appears in Exhibit 4.

The storage division was responsible for determining and maintaining proper stowage conditions and locations for material. In addition, the division was responsible for stowing material upon receipt from the receiving division, performing physical inventory and location audits on material while in storage, and issuing the material upon receipt of a requisition. The storage division was responsible for recommending the materials handling equipment requirements for warehouse operations as well as recommending the master storage space plan for the activity.

TABLE 1.

NSC Oakland Issues and Receipts

1964 to 197T

Issues

Fiscal Year	Monthly Ave. Line Items	Daily Ave. Line Items	% Chg. from Previous Year
1964	199,543	9,427	
1967	259,274	12,298	+30
1968	244,641	11,650	- 6
1969	220,231	10,487	-10
1970	182,225	8,712	-17
1971	163,608	7,775	-10
1972	161,496	7,660	- 1
1973	136,333	6,570	-14
1974	128,807	6,208	- 6
1975	128,188	6,104	- 2
1976	115,500	5,500	-10
197T	108,623	5,092	- 7

Receipts

Fiscal Year	Monthly Ave. Line Items	Daily Ave. Line Items	% Chg. from Previous Year
1964	39,063	1,845	
1967	49,242	2,336	+26
1968	48,975	2,332	- 1
1969	44,565	2,122	- 9
1970	35,879	1,715	-20
1971	31,142	1,480	-13
1972	23,122	1,097	-26
1973	26,929	1,298	+23
1974	21,972	1,059	-18
1975	22,306	1,062	+ .3
1976	22,566	1,075	+ 1
197T	20,611	966	-10

Compiled from NSC Oakland Management activity reports for period covered.

Exhibit 4

Organization of the Material Department

at NSC Oakland

Material Department Head

Deputy

- Storage Division
  - Bin Storage Branch
  - Bulk Storage Branch
  - Alameda Storage Facility
- Shop Stores Division
- Labor and Equipment Division
- Receiving Division

The head of the storage division was a senior Lieutenant Commander, Supply Corps, assisted by a deputy GS-12 who also functioned as the head of the bin storage branch. The other branch located at the main site was responsible for bulk storage and also had a GS-12 as branch head. The third branch, the Alameda cold-storage facility, essentially functioned as a separate division, although administratively it was attached to the storage division.

B. THE BIN STORAGE OPERATION

The bin storage branch was responsible for those items that lend themselves to high-density shelf storage. Ordinarily, an item was a candidate for bin storage if it weighed less than 35 pounds and occupied less than 1.1 cubic feet. The bin material complex at NSC Oakland was centered around warehouses 312, 313, 413, and 421. It consisted of some 676,676 gross square feet of storage space utilizing conventional 7 feet high shelving. In the early 1960's this facility was automated with four and a half miles of conveyor belts, programmable tote-boxes and photoelectrically actuated switching and diverting devices to facilitate the processing of receipts and issues. A warehouseman selected the material from the location stated on the issue document, placed it in a plastic tote-box, set the destination indicators on the tote-box, placed the box on the conveyor and went on with his work.

The conveyor would then carry the tote-box to its ultimate destination, untouched by human hands. This facility serviced approximately 430,000 line items of stock that accounted for 72% of the center's inventory.[1] Although the system was designed to accommodate 14,400 issues per eight hour shift, it was manned to handle 4,000 bin issues per day. The productivity rate for bin issues for 1976 averaged approximately 18 per man hour. This equated to a direct labor cost per line item of about 65 cents.[2] There were 96 warehousemen employed in the binnable complex.

C. THE BULK STORAGE BRANCH

The bulk storage branch was responsible for approximately 93,000 line items of material that occupied forty warehouses and open storage locations amounting to 7 million gross square feet of storage space. The branch was organized into two sections, 301.21 and 301.22, each under a warehouseman general foreman grade WS-09. Each section was further broken down into units consisting of several warehouses which constituted a work center. Each unit was headed up by a warehouseman foreman whose grade varied from a WS-04 to a WS-06. The organization of the bulk storage branch in early 1977 appears in Exhibit 5.

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[1] NSC Oakland Management Information Center report dated March 1977.

[2] NAVSUP Activity Management Report for Period 1/76 to 1/77.

EXHIBIT 5.

Organization of Bulk Storage Branch
NSC Oakland - 1977

Branch Supervisor

Secretary

Section 1.	Section 2.
Warehouseman General Foreman WS-9	Warehouseman General Foreman WS-9
Unit A - Bldgs. 444,542,543,544	**Unit A - Bldg. 711**
1 - Foreman WS-6	1 - Foreman WS-6
3 - Warehouseman WG-6	1 - Warehouseman WG-6
6 - Warehouseman WG-5	8 - Warehousemen WG-5
Unit B - Bldgs. 131, 141, 243,342,541	**Unit B - Bldgs. 122, 221, 222, 113, 310**
1 - Foreman WS-4	1 - Foreman WS-4
3 - Warehouseman WG-6	3 - Warehouseman WG-6
3 - Warehouseman WG-5	9 - Warehouseman WG-5
Unit C - Bldgs.343,344,442,443	**Unit C - Bldg. 522,422,113-3,531**
1 - Foreman WS-6	1 - Foreman WS-6
2 - Warehouseman WG-6	2 - Warehouseman WG-6
11- Warehousemen WG-5	1 - Warehouseman WG-5
	5 - Rigging Worker WG-6
Unit D - Bldgs.722,731,732,741/ Audit team	**Unit D - Bldg. 512/513**
1 - Foreman WS-6	1 - Foreman WS-6
3 - Warehousemen WG-6	14-Rigging Workmen WG-6
8 - Warehousemen WG-5	1 - Laborer WG-3
Unit E - Bldg.724,733,734,821, 831,832	
1 - Foreman WS-6	
2 - Warehouseman WG-6	
11- Warehouseman WG-5	

Bulk Storage Branch Personnel Summary

Warehouseman General Foreman WS-9..2	Warehouseman Foreman WS-6..7
Warehouseman Foreman WS-4..........2	Warehouseman WG-6.........19
Warehouseman WG-5.................57	Rigging Worker WG-6.......19
Laborer WG-3...................... 1	Total of.........107

Although organized by work center, the bulk storage branch head had the latitude and flexibility to shift warehousemen from a low activity work center to one that experienced an unusually high workload and required additional manpower. Additionally, both Army and Navy reservists on weekend training duty provided supplemental manpower to help make issues, or work special projects such as one-time inventories, re-warehousing or truck loading. According to Ted Toklas, the reservist provided approximately 500 man days of labor in the past year. This was equal to about 2% of the total man days available from the regularly assigned workforce. He expected the number of man days provided by reservists to go up to 1000 in the next year.

The branch head maintained continuous monitoring of all phases of the operation through several management reports. As a result of the computer run which generated the issue documents for each day, a daily distribution report was received showing the number of issues for each work center. A sample of this report is shown in Exhibit 6. This was only a general guideline to the impending workload because it did not include Issue Group I, bearer, or special project requisitions, or the second computer run of issue group two requisitions.

The military supply systems operated under the guidelines of the Uniform Material Movement and Issue Processing System (UMMIPS) whereby a matrix of urgency of need and force activity

EXHIBIT 6.

DAILY DISTRIBUTION OF ISSUE DOCUMENTS 01/06/77 Page 0001

BUILDING	BIN LINE ITEMS		BACK-UP LINE ITEMS		BULK LINE ITEMS		OFF SITES LINE ITEMS		FMS LINE ITEMS		NO ADDRESS LINE ITEMS	
ISSUE-GROUP	II	III	II	III	II	III	II	III	II	III	II	III
NO-LOCATION		3										
312	364	531							5	43	1	
313	283	1,004							10	23	3	1
TOTAL	647	1,538							15	66	4	1
412			44	102						2		
421			8	36						1		
TOTAL			52	138						3		
122/214/221/222					17	50						
131/141/243/342/531/541					15	44				2		1
310/310-C					10	9				4		
343/344/442/443					22	64				2		2
422/431/522/523					10	21				1		1
444/542/543/544/545/546					35	21				2		
512/513/613					18	32						
711					14	46						
722/731/732/741					16	17				1		
724/733/734/735					31	50						
821/831/832					58	1						
TOTAL					246	355				12		4
207-MARE ISLAND												
333-LONG BEACH												
413-LONG BEACH												
880-PT MOLATE								10				
902-ALAMEDA FACILITY							1	82				
999-LONG BEACH Y												
TOTAL							1	92				

designator determined the priority that a demand for material, or requisition, would receive in the supply system. Priority 1 - 3 were issue Group I, 4 - 8 were IG II and 9 - 15 were IG III. Based on the source of the requisition and the mode of shipment, NSC Oakland had to meet or exceed the following timeframes from entry of the requisition into the computer until completion of the picking, packing or shipping operations:

Issue Group	Priority	For requisitions referred from another activity:	For requisitions where NSC Oakland is point of entry:
I	1-3	1 day	2 days
II	4-8	2 days	3 days
III	9-15	8 days	11 days

Forty-six percent of the issues received at NSC Oakland had to be shipped in three days or less. In the month of March, 1977, NSC Oakland processed 95% of the issues on time and 97% of receipts on time.[1] NAVSUP goals for these two indicators were 92% and 85%, respectively. Of the late issues, 60% were for bulk items. In order to maintain control over the UMMIPS time frames, a Supply System Processing Time (SSPT) date was printed on the issue document. This identified the date by which material had to be issued in order to meet the UMMIPS goals. The inclusion of this date on the issue document facilitated the arrangement of work to meet time frames. At the end of the work day, each

[1]NSCO report card for March, 1977.

work center submitted a daily report to the general foreman who consolidated the individual reports into one daily report which was submitted to the branch head. Exhibits 7 and 8, although representing different time periods are examples of these reports. The bulk branch head considered 1000 issues in process and 500 disposal actions in process to be critical thresholds, indicating that the operations in the bulk branch were current if below these figures.

Issues and receipts were the most critical functions in the warehousing operation, accounting for over 50% of the activity in the branch. They were closely monitored by activity reports both locally and at NAVSUP headquarters, as they were subject to UMMIPS time frames. The remaining 50% of activity was comprised of maintenance actions associated with the storage of material. Table 2 is a breakdown of these activities based on a DoD-wide survey. Table 3 is a breakdown of these activities for three selected periods at NSC Oakland. This data shows that contrary to the popular tendency to quantify the activity in a warehouse in terms of only issues and receipts, the other types of work are significant and must be considered when determining the state of readiness in a warehousing operation.

Issues and receipts did provide a good measure of the activity in a warehousing operation and as such, performance was measured by either line items or measurement ton per month, day, or manhour. In the bulk storage branch, these production figures

EXHIBIT 7

Daily Report - Work Center

DAILY WORK CENTER REPORT (Material Dept.), BULK STORAGE BRANCH
12ND NSC 5220/32 (REV. 10-75)

REPORTING PERIOD: 3 JUNE 1977

TYPE	FUNCTION		W/U	WORK UNIT INPUT	WORK UNIT OUTPUT	WORK UNIT IN PROCESS	PRODUCTION RATE ACTUAL	PRODUCTION RATE GOAL	MANHOURS EXPENDED WORK CENTER	MANHOURS EXPENDED BORROWED	MANHOURS EXPENDED BACKLOG
DIRECT	OUTGOING BULK OPERATION	BULK ISSUE 00240	L/I	238	216	96			51		
		REPLENISHMENT 00240	L/I	Ø	Ø	Ø			Ø		
	INCOMING STORAGE OPERATION	PROCESS DOC. 00252	L/I	9	9	Ø			1		
		STOWING 00251	L/I	4Ø	4Ø	1Ø6			16		
	BIN ISSUE OPERATION	ISSUES TO CUSTOMER 00245	L/I								
		REPLENISHMENT 00245	L/I								
	SHIPPING OPERATIONS	Salvage Sorting	MT	Ø	Ø	84			Ø		
		SHIP OTHER 00400	MT	2Ø	2Ø	Ø			2		
	RECEIVE CARRIERS	UNLOADING 00389	MT	32	32	Ø			2		
	TOTAL DIRECT								72		

EXCEPTIONS	INVENTORY TALLIES		MANHOURS EXPENDED	DISPOSAL	LINE ITEMS INPUT	LINE ITEMS OUTPUT	LINE ITEMS IN PROCESS	MANHOURS EXPENDED
	00279	* 32	0	(9270) 00759 N/S Ø	Ø	Ø	43	

SUPPLEMENTARY DATA

FUNCTION		W/U	WORK COUNT	MAN HRS	RECEIVING 00389 NUMBER OF	TOTAL	PROVISIONS - ONLY
PLANNED REWHSE	00284	MT	Ø		TRUCKS WORKED	2	
WAREHOUSE	COMPLETE		Ø		RAILCARS WORKED	Ø	
REFUSALS	PARTIAL		Ø		RAILCARS IN PROCESS	Ø	

ITEMS PICK-UP		ITEMS		DATES	ISSUES	RECEIPTS	STOW
L/I 10	RCD	TALLY 132		OLDEST SSPT DATE	7160		7091
M/T 9	72	53	/ Ø	REC'D (Unusual)			

REMARKS

ISSUE WORK UNITS

BldG	INPUT	OUTPUT	INPROCESS
343	81	84	2Ø
344	55	4Ø	29
442	62	62	Ø
443	4Ø	3Ø	47
	238	216	96

MANHOURS TYPE	EXPENDED	PERCENT
DIRECT	72	
INDIRECT	Ø	
SUPPORT	12	
LEAVE	2Ø	
TOTAL	1Ø4	100%

*32 - inventory TAllies r
CounT dATE 7157

WORK CENTER	PREPARED BY	APPROVED BY	DATE
344/343 442/443	[signature]	[signature]	3 June 1977

Previous issues may be used until supply is exhausted.

EXHIBIT 8

Daily Report - Bulk Storage Branch

7154

DATE 3 JUN 197

DAILY REPORT BULK STORAGE BRANCH
12ND NSC 5220/92(MAT) (1-77)

AREA	WORK CENTER	ISSUES						RECEIPTS			STOWING			DISPOSAL			TRUCKS	RAIL CARS	CUS-TOMER PICKUPS	YELLOW
		INPUT	OUT-PUT	IN PROCESS	OLDEST SSPT DATE	WISE REFUSALS C	WISE REFUSALS P	INPUT	OUT-PUT	IN PROCESS	INPUT	OUT-PUT	IN PROCESS	INPUT	OUT-PUT	IN PROCESS				
I	344/343/443/442	238	216	96	160	—	—	9	9	—	40	40	106	—	—	43	2	—	10	—
	243/131/141/342/541	73	99	160	157	—	—	7	7	—	22	20	31	—	—	64	—	—	3	—
	444/542/543/544/545/546	45	71	—	—	—	—	52	56	—	113	131	286	—	—	756	1	—	—	—
	544-B Bins	—	—	—																
	734/733/724/821/831/832	284	306	218	159	—	—	21	21	—	61	78	71	2	—	426	1	—	66	—
	734 Bins	32	32	—																
	732/722/731/741	28	42	34	159	1	—	—	—	—	22	6	16	—	—	371	1	—	3	—
II	711	84	71	111	159	—	—	19	9	14	15	17	15	—	—	109	1	—	2	—
	122/221/222/310	224	252	145	159	2	—	—	—	—	27	32	7	—	—	672	—	—	8	—
	113/422/431/531/522	58	61	31	158	2	—	—	—	—	—	—	—	—	—	148	8	1	—	—
	512/513	102	120	102	155	—	1	10	13	2	15	14	52	—	—	58	2	—	7	16
TOTAL		1168	1270	897	155	5	1	122	115	16	315	338	584	2	—	2647	11	1	99	16

TABLE 2.

Relative Levels of Workloads (By Type)

DoD-Wide Bulk Storage

Issues	49.7%
Receipts	10.7%
Replenishments	2.3%
Inventories	5.5%
Location Audit	19.8%
P & P Issues/Receipts	5.2%
Maintainance Issues/Receipts	2.5%
Item Data Change	4.3%

From Table II-8, page 22 DoD Task Group 5-70 Phase I report.

TABLE 3.

Relative Levels of Workloads (By Type)

NSC Oakland

	'71 March-September	'72 May	'73 June
Issues	33.0%	28.7%	25.4%
Receipts	15.4%	13.4%	27.5%
Maintainance of Material in Stock	13.6%	13.8%	10.5%
Re-warehousing	2.2%	6.3%	.6%
Location Audit	3.3%	5.3%	3.0%
Expedite/Coordinate	4.6%	4.7%	3.5%
Supervision/Clerical	8.2%	8.5%	10.7%
Annual/Sick Leave	15.4%	11.6%	13.6%
Other Miscellaneous Functions	4.3%	7.7%	5.2%

Compiled from bulk storage branch work center records.

varied widely, depending on the nature of the material handled. Typically, items that required special handling such as rigging or cutting had very low line item productivity figures per man-hour. Steel, cable and boiler tubes were examples of material in this category. Materials that were issued in large quantities, while having an adverse effect on the line item productivity figures, did provide high measurement ton productivity figures. Paint, sonobuoys and firebrick, where many pallets of material account for a single line item issue, were examples of this category of material. However, over a three month period from April to June 1976, the bulk storage branch averaged 1104 issues and 368 receipts per day. Exhibit 9 gives a breakdown of issues, receipts and personnel assigned by work center for this period.

All demands for material were recorded in a historical file under the Uniformed Automated Data Processing System for Stock-points (UADPS-SP) programs. Utilizing this historical demand file information in conjunction with the Master-Stock Item File (MSIR), it was possible to produce management reports that indicated various profiles of the inventory. When the demand frequency analysis program was run in April, 1976, for the warehouses surveyed, it indicated that 17.7% of the line items carried accounted for 86% of the demands for the period of the survey. This finding is consistent with earlier surveys that led to the establishment of the Selected Item Management (SIM) concept for inventory and material control. These findings

EXHIBIT 9.

Average Daily Output for April - June 1976

Bulk Storage Branch

Area	Work Center	Average Issues/Day	Average Receipts/Day	Personnel Assigned
I				
	711	88	17	8
	731/732/741/722	60	14	3
	734/724/733	210	46	10
	821/831/832	27	24	4
Area II				
	122/221/222/ 214/113-2&4	155	31	9
	310	29	13	2
	522/422/113-3 431	45	14	8
	513/512	144	26	17
Area III				
	343/344/442 443	202	35	13
	531/541/131 141/342/243	105	35	10
	544/444/543	39	113	11

indicated that 15% of an activity's inventory accounted for 85% of the demand. A more recent study, conducted by DoD in 1970 disclosed that for bulk items, 15.3% of the items stocked accounted for 79.8% of the issues made.[1] Under SIM, management attention was focused on these items with regard to inventory control and storage location. NSC Oakland management recognized this fact and had done some analysis on what constituted a fast-moving item. One study prepared by their staff in February 1975 concluded that any bulk item that experienced a frequency of demand of 18.5 or more per year should be treated as a fast-moving item and located in a centralized storage location. No substantial re-warehousing program had been undertaken as a result of this study. The memorandum containing the models for determining the fast-moving bulk items appears in Appendix B.

In April 1977, as a result of a reorganization in the Navy Commissary Distribution Office, a tenant activity at NSC Oakland, eight warehousemen had been absorbed into the workforce at the supply center. It was decided by the Executive Officer, CAPT Ferraro, to employ these men in a warehousing project designed to consolidate fast-moving bulk items and to isolate slow-moving bulk items in warehouses that could be closed most of the time. Alex Webster, Warehouseman General Foreman, Area I, was assigned full-time to this project to develop the plans and procedures that appear as Appendix C.

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[1] DoD Depot Storage Facility Modernization Phase I Final Report Task Group 5-70 of the Logistics Systems Policy Committee, Dec 71, Vol. II, page 18.

In response to the request of the Executive Officer that in the interest of efficiency, warehouses be closed if possible, Ted Toklas issued a memorandum on 18 April 1977 that designated certain buildings that would only be open two days a week if certain conditions were met. Appendix D is a copy of this memorandum.

D. OPERATIONS AND FACILITIES IN THE BULK STORAGE BRANCH

As mentioned earlier, approximately 93,000 line items of stock were stored in 35 warehouses in the bulk storage branch. Daily operations consisted of making issues, offloading trucks and railcars, stowing receipts, re-warehousing, and stock maintenance. Issue Group II and III documents in the form of DD 1384-1 forms were generated by the data processing department located in Building 311 and delivered to the appropriate work center by storage division messenger, prior to the start of the working day. These documents, an example of which appears as Exhibit 10, had to be manually arranged in location sequence according to the type of item within the warehouse. In addition, Issue Group I documents were printed on a remote unit in the Storage Control Section located in Building 313. These were delivered by messenger or picked up by the warehousemen if the messenger would not be able to deliver them within an hour.

The standard method of making an issue in bulk storage was for a warehouseman to mount a fork-lift truck and drive to the

EXHIBIT 10.

EXAMPLE OF DD1348-1 ISSUE DOCUMENT

DOC IDENT	RI FROM	M & S	STOCK NUMBER (FSC / NIIN / ADD)	UNIT OF ISSUE	QUANTITY	DOCUMENT NUMBER (SERV / REQUISITIONER / DATE / SERIAL)	SUFFIX	SERV	SUPPLEMENTARY ADDRESS	SIGNAL	FUND	DISTRIBUTION	PROJECT	PRIORITY	REQ'D DEL DATE	ADVICE	RI	UNIT PRICE (DOLLARS / CTS)

A01NOTS8430006242746 PR00036N00651714247O1 YSTOCKAN6 9D77012 AARD0002070

SHIPPED FROM	SHIP TO	MARK FOR	PROJECT	TOTAL PRICE (DOLLARS / CTS)
(228) NAVAL SUPPLY CENTER OAKLAND, CALIF	N00651	YSTOCK	770	00074520

WAREHOUSE LOCATION		UNIT PACK	UNIT WEIGHT	UNIT CUBE	U F C	N M F C	FREIGHT RATE		DOCUMENT DATE	MAT COND	QUANTITY	
735 003 20 8		006			A01		234058170		715C	A	CC036	PR CY139

SUBSTITUTE DATA (ITEM ORIGINALLY REQUESTED)	FREIGHT CLASSIFICATION NOMENCLATURE	
		SSPT 161
	ITEM NOMENCLATURE	
	#05331 W C	

SHIPPERS USE			RECEIVERS USE	
SELECTED BY AND DATE: 7150	TYPE OF CONTAINER(S)	TOTAL WEIGHT	RECEIVED BY AND DATE	INSPECTED BY AND DATE
PACKED BY AND DATE	NO. OF CONTAINERS	TOTAL CUBE	WAREHOUSED BY AND DATE	WAREHOUSE LOCATION

REMARKS				
	BLDG 333C	SUBIC MAJ		

FIRST DESTINATION ADDRESS	DATE SHIPPED		
159		A SS	1515039 TR V Z

13 TRANSPORTATION CHARGEABLE TO	14 B/LADING, AWB, OR RECEIVER'S SIGNATURE (AND DATE)	15 RECEIVER'S DOCUMENT NUMBER

2

DD FORM 1348—1 1 MAR 74 EDITION OF 1 JAN 64 MAY BE USED UNTIL EXHAUSTED DOD SINGLE LINE ITEM RELEASE/RECEIPT DOCUMENT

FES4 FC38 TIME 02 29 REEL # 02722 77151

material, select the required item or items, place on a pallet, and stage the material with documentation in the center aisle or outside the warehouse to be picked up by a straddle truck for delivery to shipping.

The receiving operation was handled both at a central receiving area in Buildings 212 and 421 and directly at the warehouses. The ratio of central receiving to direct receiving was 4:1 on a pallet basis but 1:1 on a cubic volume basis, according to Ted Toklas. Receipts were delivered on pallets to the appropriate warehouse either by straddle truck, which had a capacity of 6 to 8 pallet loads, or by carts pulled by a driver controlled tractor. The carts had a capacity of 2 to 4 pallets depending upon the characteristics of the material. Quite often, receipts of a large quantity of a single line item, such as a truck load of boiler tubes, would be delivered directly to the warehouse where they were to be stored. This operation was not limited to those warehouses which had loading docks, because a wheeled 35' yard ramp was used to discharge trucks at a ground level building. Receipts were delivered with the necessary documentation to determine location in most instances. The material was transported to its ultimate location by forklift, stowed, and the proper documentation input to establish a record of the transaction. Frequently, due to the dynamic nature of the inventory, receipts had to be stored in a different location and a change notice effected. As mentioned earlier, the warehousemen had no knowledge of receipt type, quantity or arrival date. Often, as a result of increased stockage levels

determined by the inventory control point, a new receipt would not fit in the old location. The options open to the warehousemen were: (1) use secondary and tertiary locations as necessary to accommodate the overflow, (2) completely re-warehouse the material to accommodate it in one location if possible. The latter alternative was preferred to the former by most Navy warehousing personnel. However, the effort to re-warehouse could be enormous in a crowded warehouse with little slack capacity. It was estimated from one study that the cost to re-warehouse a measurement ton was $4.51.[1] One fully loaded pallet, approximately 48"x40"x48", was generally regarded as a measurement ton.

As a result of a location survey in April 1976, of the 17 warehouses surveyed, there were 42,000 primary locations, 3,800 secondary locations and 300 tertiary locations. Most of these secondary and tertiary locations were adjacent to primary locations and used to accommodate items with large quantities that would not fit in a primary location. Examples of these commodities were light bulbs, firebrick, and rope, where often as high as 100 pallets constituted the stockage objective.

All of the warehouses used at NSC Oakland were constructed during World War II. Some were constructed as permanent structures, others were designed and built as temporary structures.

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[1] NSC Oakland Memo 500/WTL: le dated February 19, 1976, page 1, enclosure (2).

Thirty years later, these "temporary" structures were still being utilized for storage of material. Most of the warehouses had interior supporting members which complicated storage aid layout and contributed to wasted storage space. Many of the warehouses had substandard incandescent lighting. In some warehouses, as a result of energy conservation programs, every other light had been deactivated, further aggravating an already acute lighting problem. Maximum floor loading in most warehouses was 500 pounds per square foot. Exhibit 11 is a tabulation of information for the most important bulk storage warehouses. Exhibit 12 shows the distribution of forklift trucks by work area.

E. THE AUTOMATION OF WAREHOUSES IN THE NAVY

The increasing demands upon the Naval Supply System and the continuing need for greater economy and efficiency in its operations and techniques had prompted the old Bureau of Supplies and Accounts (the forerunner of NAVSUP) to undertake a feasibility study on the introduction of automation into warehouse operations in 1957. Twenty commercial and Air Force facilities were visited in an attempt to ascertain the extent to which automation was being applied in their operations. Outstanding examples of extensive mechanization were found at all Air Force installations visited and the warehouse operations of the other activities visited were mechanized to various degrees, depending upon their particular requirements. After analyzing the information available from these activities, the study focused

EXHIBIT 11.

NSC Oakland Bulk Warehouse Information

BLDG NO.	DATE CONST.	AREA SQ.FT.	CONST. TYPE	USE	NO.L/I CARRIED	REMARKS
122	1944	190,792	Single level-20' ceiling	Cable,wire,hose& gasket material stored on pallets &on floor.	5,100	Built on landfill foundation settling.
221	1942	N/A	Single level-12' high ceiling	Storage of bulk forms and publications on pallets.	1,389	Rail dock &truck dock,each with 2 car or truck capacity.
222	1942	N/A	Single level-12' high ceiling	General bulk storage.	3,797	
310	N/A	510,435	Multi-floor (5) average stacking height of 9'	2nd floor -security, 3rd&4th slow moving bulk	10,879	Rail&truck docks, freight elevator to upper floors.
342 442 542	early 1940's	342,455 total	Single-level, average stacking height of 14'	342,542 Fast moving bulk stored in pallet racks up to 4 high 442-Sonobuoys	2,997 283 3,088	
343 344 443	early 1940's	365,169 total	Single level 12' stacking height	Fast moving bulk items stored in metal & wooden pallet racks.	2,659 1,759 1,162	
412	1940	73,285	Single level low ceiling-10'average stacking height	Security area for storage of highly pilferable items	N/A	Covered docks on both sides.
442 522	1942	13 mil. cubic ft.	Aviation airframes storage-57'high ceiling in main area,mezzanines on each side with 16'high stacking above&20' below	422-boats&large bulk. 522-boiler tubing&parts, nuclear submarine pipe and metal.	2,227 5,236	600 pound per sq ft floor loading.

DATE AREA NO. 1/I

BLDG NO.	DATE CONST.	AREA SQ.FT.	CONST. TYPE	USE	NO.L/I CARRIED	REMARKS
431	1942	105,600	Single level-12' to 20'stacking heights	Receiving,storage & issuing of hazardous material.	408	Covered platform docks.
444 543 544	early 1940's	358,797 total	Single level average stacking height of 10'	Repairable&general bulk storage.	1,791 4,287 9,210	Wooden&metal pallet racks used for storage aids.
512 513	1941	N/A	Single level-22' clearance under crane	Steel plate,sheet,rod, bar, angle.	638 4,067	Cantilever racks in Bldg. 513.
541	1944	120,000	Single level,average stacking height of 10'	General bulk.	2,981	Metal&wooden pallet racks.
531	1941	120,751	Single level,ceiling height from 14' - 30'	Lumber,empty containers, misc. bulk.	530	1000 lb per sqft floor loading. PWC est.for roof repair in '69 was $165,000.
711	1943	119,698	Single level low ceiling.	Packaged oil & lubricants,cylinders,poisons.	1,717	Few storage aids utilized.
743	1943	119,340	Single level low ceiling.	Receipt, storage of clothing & textiles.	5,340	Pallet racks,bins used as storage aids packaging operation in building.
724 733 831 832	early 1940's	N/A	Single level low ceiling	733-slow moving lge. electronics bulk 832-pumps/pump parts	2,040 1,117 1,257 980	Wooden pallet racks used as storage aids
722 731	early 1940's	N/A	Single level low ceiling.	Slow moving bulk items such as valves,fittings electronics & pumps & fans.	2,146 1,587 3,390	Wooden pallet racks used as storage aids.

EXHIBIT 12.

FORKLIFT DISTRIBUTION BY WORK AREA

AREA	3000 lb. Capacity	4000 lb. Capacity	6000 lb. Capacity
122/221/222		8	
131/141/243/342/541		5	1
310/1st floor		3	
310/2nd-4th floor		1	
343		10	
422/522/531/431		4	2
444		7	1
512/513		2	7*
711		2	4
722/731/732/741	2	4	
724/733/734/821/831		10	1
TOTALS	2	56	16

Average age = 10.9 years.[1]

Average operating and maintenance cost = $4.25/hour.[1]

* includes 3 sideloaders (wire guided).

[1]Computed from information contained in NSC Oakland letter 40A:ELP:SV of 6 May 1976 - reply to DoDMDS data call for mobile equipment data.

on determining those areas of the Navy Supply System to which automated materials handling techniques might be applied. After carefully analyzing the four basic operations encompassing the warehouse system of a typical Naval Supply Activity -- receiving, storage, packing, and shipping, the study concluded that the issuing and sorting elements of the storage operation appeared to be the most suitable for automation. The Bureau of Supplies and Accounts then contacted selected materials handling equipment manufacturers and encouraged them to visit several typical Navy warehouses, including NSC Oakland, for the purpose of observing operations and submitting informal proposals on those areas of materials handling that appeared to be susceptible to automation. Most of these studies, while not offering any specific application for automation, did confirm that some degree of automation was possible in Navy warehousing. The Bureau concluded that automating the stock picking function at Navy warehouses should receive first priority. After four equipment manufacturers had submitted formal proposals to conduct detailed evaluation studies for application of automation to this function, the Bureau decided to abandon this effort due to the high cost involved and because the proposals did not solve the major problem, the picking of unpackaged bin materials. Studies conducted by the Bureau had revealed that about eighty percent of the items in the Supply system were susceptible to bin storage and that these binnable items, while only occupying ten percent of the storage space,

accounted, item wise, for seventy-five percent of issues.[1] The Bureau felt it should concentrate its efforts on those material handling functions that appeared easiest and least costly to automate. Based on the investigations and studies, these were the materials handling operations involved from the time an item was picked in a bin area to the time it was delivered to a packing station. To proceed with the development of an automated system to handle these functions, the Bureau of Supplies and Accounts requested the Naval Supply Depot in Bayonne, New Jersey, to conduct a study of bin storage and issue operations. The Bayonne study was completed in July 1959 and served as the basis for the design and development of automated handling systems that were installed in five of the major stock points.

In January, 1961, an automated system for the handling, moving, sorting and accumulating of binnable material, featuring conveyors, accumulators, sorters, and a controlling console was activated at the Naval Supply Depot Bayonne. Installed by Rapids-Standard Co., Inc., Grand Rapids, Mich., it cost $449,000 and had a projected annual rate of savings of $260,000.[2] By January 1966, similar installations had been completed at NSC Norfolk, NSC Oakland, NSC Charleston, Naval Shipyards Long Beach and Puget Sound and the Naval Supply Depot in Philadelphia. Each of these systems was individually tailored to the business

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[1]Automated Materials Handling Systems in United States Navy Warehouses, LCDR Charles W. Long, Thesis published 15 April 1965, G. W. University, p. 39.

[2]IBID, p. 73.

volume and the warehouse structural characteristics of the particular activity. All systems were centrally operated, electronically controlled, electrically powered conveyor systems used for the movement of material received into or issued out of a storage warehouse.

The automated materials handling system at NSC Oakland is the Navy's largest, encompassing 14 floors of four buildings and 4-1/2 miles of conveyors. The system sorted material by the type of pack required, consolidated material by customers, dispatched material to packers according to automatically determined line loadings, returned empty tote boxes to appropriate issue areas, dispatched receipts to storage areas, transported complete packages to shipping areas and dispatched replenishment materials to the various storage areas.

Additional systems were installed in Naval Supply Centers Pearl Harbor and Subic Bay in the Philippines, Naval Air Stations Jacksonville, Norfolk and North Island, San Diego between 1966 and 1970. Total expenditures from installation of the first system in 1960 through fiscal year 1970 were approximately $12 million. Annual savings effected by the installation of these systems was in excess of $4 million in personnel alone.[1] Considering the savings in personnel costs only, the total expenditure had been amortized in less than three years. Other savings had also accrued, but they had not been measured as precisely as personnel savings. Reduction had occurred in the requirements

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[1]DoD Depot Storage Facility Modernization Phase I, Final Report TASK Group 5-70 of Logistics System Policy Committee Dec. 1971, Vol. IV, pg. 35.

for conventional materials handling equipment; savings had resulted from combining orders to reduce the requirements for packaging materials and reduced transportation costs; savings had resulted in reduced storage space requirements through consolidation of material in a centralized area for compatibility with system movement; and savings had resulted from improved paperwork procedures in association with the systems.

With the application of automation systems to the bin issue activities virtually completed by 1971, the Navy directed its attention to the handling of bulk materials.

In a 1972 presentation to the Naval Supply Systems Command Executive Board entitled "Warehousing Improvement Program," the warehousing branch of NAVSUP recommended, inter alia, that "the most apparent need for complete new mechanized or automated systems was found to be for bulk palletized materials; metals handling; receiving; shipping; and packing and packaging areas."[1] Reference was made to existing high rise automated storage retrieval systems in operation at the Defense Depot, Memphis, Tenn.; Red River Army Depot in Texarkana, Texas, and Naval Air Rework Facility in Norfolk. In 1977, the tangible evidence of progress in this area was at NSC San Diego where a high-rise automated storage and retrieval system was in the architectural and engineering stages. Due to funding constraints, no estimated date for implementation was available.

[1] Naval Supply Systems Command Presentation to the Executive Board, 20 September 1972, page 11.

F. THE 1970's - A TIME FOR STUDIES

In February, 1971, the Assistant Secretary of Defense for Installation and Logistics, Mr. Shillito, in his capacity as Chairman of the Logistics Systems Policy Committee signed Task Force Order 5-70, directing the DoD Depot Storage Facility Modernization Study. The Task Order requested the Defense Supply Agency (DSA) to undertake chairmanship of Phase I, Data Collection, of a joint task group composed of representatives from the Office of the Secretary of Defense (OSD), the military services, and DSA to look to maximum utilization of the expanding technology of the period, to create a depot storage facility configuration free of current and past physical constraints. This facility was to be geared to the compressed time frames posed by electronics processing, the realities of changing wholesale/retail stockage mix, and the ever-increasing responsiveness demanded by emerging concepts of logistics support. The Task Order requested the group to focus on the 1975 to 1980 time frame and to develop cost-effective alternatives for the modernization of DoD storage facilities which would, to the maximum extent practicable, increase efficiency, increase responsiveness to customers, and decrease life cycle costs. The Phase I report was published in December 1971 and contained a review of all existing storage systems, equipments and facilities in use by the major depots in DoD. The data collected and collated by the Phase I effort was to be utilized during the

phase II effort which was to analyze the data and test alternative systems and facilities for effectiveness, efficiency, feasibility and economy. Additionally, the Phase II report was to develop summaries of depot systems currently in use, and plan for expansion, contraction, reorganization and future modernization. This effort was completed in December, 1972.

The Phase III effort was to recommend DoD actions to phase optimum storage facility systems into being, and to insure attainment of the best possible facility with justifiable expenditure of funds and effort. The Department of Defense Material Distribution Systems Study Group (DODMDS) was formed for the purpose of recommending improvements which would effectively and economically support the services' requirements in both peacetime and under mobilization. As a part of the overall mission of DODMDS, the Distribution Center Design and Modernization Task Group (DAMTG) was specifically charged with the responsibility of developing an implementation plan for the modernization of existing facilities and construction of new supply distribution depots. Essentially this group was to fulfill the spirit of the intent of the Phase III effort. The group issued a new data call early in 1976 to the participating DoD activities in order to obtain more up-to-date statistics on which to base their analysis. It was anticipated that a preliminary report would be forthcoming from this group in December 1977.

Roach Report

As a result of the Chief of Naval Material Inspector General recommendation in early 1973, the Naval Supply Systems Command (NAVSUP) issued a contract worth $275,000 to Roach Systems, a Division of Roach Manufacturing Company, Trumann, Arkansas, for the preparation of Warehouse Modernization Reports for NSC's Norfolk, Charleston, San Diego and Oakland. The statement of work in the contract stated that

> "a comprehensive modernization plan is to be developed for the Naval Supply Systems Command, including warehouse facilities handling equipment, systems and operations for the Naval Supply Centers. The discrete plan for the Naval Supply Centers is to include the latest state-of-the-art technology for processes and facilities and is to be designed to improve efficiency, responsivenesses, quality, pollution abatement, and safety in a cost-effective manner.
>
> The plan and its subsequent implementation should be designed to avoid or minimize interference or interruption of operations at the Supply Centers. The plan is to be developed with the objectives of determining requirements, determining usable/modernizable assets, comparing assets with requirements to determine deficiencies, and developing a plan to eliminate such deficiencies. The plan may propose modernization of existing buildings and equipment or replacement of some buildings and equipment while modernizing others, or complete replacement of the entire Integrated Supply Facility with an ideal prototype."[1]

In the Roach reports, mention is made of the fact that recent research on warehouse layout had concentrated on the objective of determining layout designs which minimized the distance traveled in order picking. In addition to the warehouse layout problem, there existed a warehouse re-layout problem.

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[1]Warehouse Modernization Report, NSC Oakland, California, Roach Systems, 8 May 1975, page 1-7.

In recognition of the dynamic nature of the storage function, it was emphasized that as storage demands change, so should storage layouts. According to the analysts on the project, "to effect a responsive layout system requires usage data, as well as other inventory control related data. Consequently, a management information system must be designed to interface the inventory control system and the stock location system."[1]

The Roach studies recognized the fact that one of the major costs to the centers was material handling. As such, it was not surprising to see that the majority of their recommendations centered around attempts to reduce this cost. The analysts recognized that a large percentage of the line items stored in individual warehouses were not demanded frequently enough to justify the assignment of personnel and material handling equipment. They recommended that a popularity analysis should be performed to segregate those line items that were experiencing demands from those line items that were not active.

The Roach Modernization Plan for NSC Oakland had the following features: (1) consolidation of bulk and bin storage, retrieval and internal stock activities, (2) higher utilization of cube storage and warehousing space, (3)modernization of stock picking and warehousing functions, and (4) integration of the packing, shipping, and receiving functions with those of pallet

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[1] IBID., page 2-63.

storage and retrieval. A specific recommendation in the report was the consolidation of all fast-moving bulk items into two modernized facilities. This was to be accomplished through the implementation of a modern, high-rise narrow aisle storage configuration integrated into the existing materials handling system. Based on the flow of material and delivery frequencies, the following macroscopic design was recommended:

> "obtain more efficient cube utilization in buildings 422 and 522 by the addition of high-rise, narrow aisle, pallet storage racks serviced by storage/retrieval machines. All fast-moving bulk currently being stored in buildings 342, 343, 344, 442, 443, and 734 should be moved into the new pallet system in buildings 422 and 522."[1]

From the economic analysis section of the report, the following standard costs were obtained:

Labor (including fringe benefits)	
(1) Warehouseman	$12,000/year
(2) Labor and Equipment	13,000/year
Equipment Operating and Maintenance	
(1) Forklift truck	$ 4,000/year
(2) Straddle truck	6,000/year
Building Utilities and Maintenacne	
(1) Existing Buildings (Active Status)	22¢/SF/year
(2) Existing Buildings (Inactive Status)	3¢/SF/year
(3) New Buildings	17¢/SF/year
Material Handling Equipment (10-Year Life)	
(1) Stacker/Retriever System for 500' aisles 50' high racks - per aisle	$400,000
(2) Stacker/Retriever System for 500' aisles 20' high - per aisle	$200,000

The Roach report concluded that in addition to installing a high-rise automated storage retrieval system in buildings

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[1]IBID., page 4-3.

422 and 522, two new buildings should be constructed on the main site to accommodate the provisions currently stored at the Alameda cold storage facility and to accommodate the cable, POL, steel and hazardous items stored in other bulk warehouses at the main site. They additionally proposed a driverless tractor system to connect the modernized and new facilities with the shipping and receiving operations. With an estimated cost of $31,280,000, their proposal clearly fell in the long-range category, even though, based on their economic analysis, it did exhibit a 1.05 savings/investment ratio. This ratio is defined by SECNAVINST 7000.14A of 14 March 1973 as the result of the total present value of savings divided by the total new present value of the investment, over the economic life of the project.

G. THE HIGH-RISE CONCEPT AT NSC OAKLAND

The recommendation in the ROACH report to install high rise, narrow aisle, pallet storage racks serviced by storage/retrieval machines came as no surprise to Ted Toklas. As early as 1970, Ted began to see advertisements for high-rise systems in the material handling equipment trade magazines.

Ted was a member of several organizations that were dedicated to the advancement of the theory and practice of integrated material movement and material handling systems including the International Material Management Society. He regularly read several trade magazines and was interested in improving the material management in his branch.

In 1972, he learned of a prototype installation at the Naval Air Rework Facility, Alameda, and after viewing this in operation, felt a similar installation would be beneficial at NSC Oakland. He wrote to the manufacturer, Triax Corporation, of Cleveland, Ohio, and received descriptive literature which included a system installed at the Formica Corporation in Sacramento, California. Ted subsequently visited the Formica installation and reported his findings in a memorandum to the Material Division Officer. Appendix E is a copy of this report and the attached routing slip which indicated that only a passing interest was generated among the top management in the Material Division.

The high-rise concept received no further attention until 1974, when Commander Plante, the director of the Material and Facilities Division in NAVSUP, visited NSC Oakland and encouraged Ted Toklas to submit the proposal to NAVSUP. From 1974 until the ROACH report in May 1975, the concept was under passive consideration. The ROACH report again stirred active interest in the concept which was once again overtaken by more pressing events. Finally, from April until July 1976, Ted Toklas collected supporting data for a submission to NAVSUP. In August, 1976, Ted spent 3-1/2 weeks full-time preparing a final proposal. Appendix F is a copy of the justification sent to NAVSUP.

1. <u>The NAVFAC Report</u>

As an adjunct to the automated high-rise storage retrieval proposal, NSC Oakland requested the Western Division of the Naval Facilities Engineering Command (NAVFAC) to conduct an investigation of the floor-loading capabilities of building 422 and to provide a method and cost estimate for increasing the live floor loading from 500 pounds/square foot to 1,800 pounds/square foot. The report, attached as AppendixG estimated the cost to be approximately 1.2 million dollars.

Receipt of this report at NAVSUP prompted suspension of activity on the Oakland proposal pending results of the bid openings for the NSC Norfolk steel handling modernization project, which encompassed similar floor loading problems. The timetable for the NSC Norfolk project was: bid opening - 24 March, completion of evaluation of technical proposals - 27 May, award of the contract - 15 June. In the interim, NSC Oakland was advised to follow-up on the NAVFAC recommendations for additional core samples and piling examinations.

In conversation with Mr. Paul Chaen Kwok, Mechanical Engineer GS-13 NAVSUP Code 0332, on 6 May 1977, the casewriter was informed that the bid opening date for the NSC Norfolk steel handling project was extended to 25 May to allow one system manufacturer to bring a general contractor into the bidding.

IV. THE NAVY SYSTEM GOVERNING MODERNIZATION

Justification for mechanization and automation had to be in the form of an economic analysis in accordance with NAVSUP Instruction 7000.10A of 29 October 1974, and normally included a choice or comparison between two or more options. A determination of benefits and costs was also encouraged for single option investment proposals, i.e., those proposals lacking feasible alternatives that could be evaluated. Such analysis was required for consolidation projects for warehouses and storage depots to increase efficiency; modernization projects to mechanize, prevent obsolescence, improve workflow and layout, or increase capacity which could lead to a reduction in costs; and material or supply handling projects to increase efficiency and capacity.

The major program for ashore supply activities, including design and development of material handling systems was being developed by NAVSUP code 0332, Material and Facilities Division, Fleet Support and Supply Operations, headed up by Commander R. E. Plante. He was assisted by a GS-14, Mr. R. Lee, who headed up the Material Handling Equipment and Systems Branch. The office staff consisted of one mechanical engineer GS-13, two industrial engineers GS-12, and one mechanical engineer GS-11.

The systems approach employed by NAVSUP required that the total operation be analyzed and planned in order that individual improvements would effectively integrate within the total design.

Responsibility for budgeting, design, procurement, and installation coordination of equipment systems used in warehouse mechanization/automation was assigned to NAVSUP on 1 July 1964.[1] This responsibility included equipment which was powered and nonpowered, fixed and mobile equipment used to convey materials <u>except</u> those conveyors utilized in the extracting, handling, and storage of bulk materials such as gases, liquids, semi-liquids, and solids; conveyors utilized in conjunction with fabrication processes or machine tool operations; pneumatic tube systems; and conveyors which were an integral part of a ship's design.

The philosophy of NAVSUP with regard to warehouse modernization was expressed by Commander Plante when he stated,

> "the most crucial factor in any decision to automate is the identification of the simplest and most reliable state-of-the-art equipment or system to do the job. Any system more sophisticated or greater in capacity than what the character of the material and the throughput requires should be scrupulously avoided, with the only possible exception being consideration for future growth, based on a sound projection of quantifiable increased workload of a compatible type."[1]

Two types of funding were utilized in the modernization of warehouses in the Navy. Military Construction Program (MILCON) funding was utilized to construct new buildings and facilities. Other Procurement, Navy (OPN) funds were utilized to procure equipment and systems.

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[1]DoD Depot Storage Facility Modernization Phase I Final Report, Task Group 5-70 of the Logistics System Policy Committee, Dec. 1971, pg. 359.

[1]"The Navy's Warehousing Program..Today and Tomorrow," CDR Rene E. Plante, SC, USN, Navy Supply Corps Newsletter, Vol. 40, No. 4, April 1977, pg. 25.

The allocation of MILCON funding at NAVSUP was based on the level of activity at each Supply facility. Since NSC Norfolk accounted for 42% of the total Navy Supply business, it was the recipient of the largest share of the MILCON funds.[2] The priority for modernization at NSC Oakland was stated to be not as high as say, NSC Charleston, because Oakland's facilities were generally in better condition than many of the other supply activities.

The availability of MILCON funding for warehouse modernization traditionally had been very low. The Chief of Naval Operations (CNO) had designated Special Emphasis Programs in the MILCON funding arena that were designed to reduce the overall backlog of MILCON requirements. The CNO had segregated funds to assist these programs which included TRIDENT, pollution abatement, shipyards, airfields and utilities. The remaining MILCON funds were budgeted for all regular construction. The total Navy MILCON funding for fiscal year 1977 was 800 million dollars. After Special Emphasis Program funds had been segregated, NAVMAT was left with 35 million dollars to be allocated among the various systems commands, including NAVSUP.

NAVSUP had identified 150 million dollars worth of requirements, but no dollars were programmed for construction in FY77. In fact, there were only three projects that were programmable

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[2]The information on MILCON funding was obtained from an interview with CDR Mike Carricato, CEC, USN, Head Facilities Maintenance Branch, Material and Facilities Division, NAVSUP, in February 1977.

in the FY77-82 time frame -- the high-rise storage retrieval system at NSC San Diego, a cold storage facility at NSC Norfolk, and a container stuffing and stripping facility at NSC Norfolk. There was no provision for military construction at NSC Oakland in the Five Year Defense Plan for 1977-1982.

In the realm of equipment and systems procurement, OPN funds were based on budget ceilings established by NAVCOMPT and DoD. NAVSUP was obliged to try and maintain their basic programs within the control figures established by NAVCOMPT and DoD. A very strong justification was required to exceed this figure. The Materials and Facilities Division maintained a working document for all modernization proposals called a Budget Item Justification Sheet. This document was reviewed every six months and provided the input for the Program Objectives Memorandum (POM) for warehousing improvement. The POM was the document used to submit NAVSUP's requirements for warehouse modernization in the Five Year Defense Plan. A proposal from a field activity, if submitted in accordance with the NAVSUP Instruction 7000.14A, was reviewed by NAVSUP Materials and Facility Division to determine feasibility and desirability and included in the Budget Item Justification Sheet, provided funds were available. In general, the shorter the payback period, or the lower the investment/savings ratio the greater the probability of being included in the budget. Funds availability for FY77 was approximately 3 million dollars, with 4 million dollars projected for FY 1982.

In September-October of 1976, approximately 2 million dollars of OPN funding was identified as being available for use on productivity enhancing projects that showed a payback period of two years or less. As of May, 1977, only 20% of this money had been programmed and a recent letter from the new Commander of the Naval Supply Systems Command, RADM Grinstead, to the Commanding Officers of field supply activities had encouraged them to submit projects that could qualify for funding under this separate program. The deadline for submission was May 20, 1977.

V. REESTABLISHING THE DATA BASE

Due to the non-availability of supporting data from the earlier NSC Oakland high-rise proposal, it was decided that a new data base would have to be established in order to evaluate alternatives in light of the questionable likelihood of obtaining the original high-rise system.

From the NSC Oakland Location Audit Schedule for FY 1977, it was determined that there were 93,291 line items in 117,995 locations in bulk storage warehouses. In order to determine how many of these items would be candidates for some form of modernized warehousing, it was first necessary to establish a selection criterion. The most obvious and readily available statistic was frequency of demand, a measure of activity for the item. Once a demand profile was established for an item,

it was then possible to compute an expected frequency of movement because all other material handling operations such as receiving, issuing, inventorying and re-warehousing were a function of demand for the item.

The Uniform Automated Data Processing for Stock Points (UADPS-SP), management report program FC10 "Demand Frequency Analysis by Location" was utilized to identify those items that would be candidates for modernization based on demand frequency. This program had the ability to scan the Master Stock Item Records (MSIR) by location and demand frequency and to provide an output in the format of Exhibit 13. The period of demand included in this report was from 23 August 1973 until 8 March 1977, a period of 184 weeks. The program was set to recognize those National Stock Numbers (NSN'S) that had experienced a frequency of demand greater than 51 for the period of review, or slightly more than 1 demand per month.

Certain warehouses were excluded from this review due to the nature of the material stored in them. Repairables, corrosives, sonobuoys, iron and steel, gases, boiler tubing, and nuclear submarine components, due to their special handling characteristics, were deemed not to be conducive to the modernized systems under consideration. A list of warehouses excluded from the review, and the type of material contained in each, is shown in Exhibit 14.

EXHIBIT 13.

FC 10 DEMAND FREQUENCY ANALYSIS BY LOCATION

LOC	TOTAL DEMAND FREQ. QTRS	NUMBER NSN	NUMBER L/I DEM	NUMBER NSN SEC LOC	NUMBER NSN TER LOC
221	0				
	1-2				
	3-5				
	6-11				
	12-18				
	19-25				
	26-50				
	51+	44	5,857	7	

FC10 SYMBOL 221 DEMAND FREQUENCY ANALYSIS CARD LIST

PRI LOC	SEC LOC	TER LOC	NSN/SMIC	CC	UI	FREQ
221000000			0102LF0131030	A	BX	0243
221000000			0103LF2001040	A	PG	0167
221000000			0104LF7002061	A	HD	0093
221000000			0104LF7030670	A	PG	0077
221000000			2530004931986	A	EA	0107
221000000			4320005404389	A	EA	0159
221058070			0105LF2012602	A	PG	0093
221058090	221054080		5307008238815	A	EA	0107
221067090			6625004752714	A	EA	0096
221069080			4820005415699	A	EA	0069
221069100			4910002198392	A	EA	0067
221085260			9390007204465	A	EA	0068
221088070			0103LF20192004	A	PD	0157
221095130			0106LF0163005	A	PD	0063

EXHIBIT 14.

WAREHOUSES AND TYPES OF MATERIAL EXCLUDED

FROM DEMAND FREQUENCY PROGRAM RUN

BLDG/AREA NR.	TYPE OF MATERIAL STORED
113	Small arms
131 141	Large motors, slow moving large bulk
214	Radioactive
310	Classified
412	Pilferable items
422	Boats, large slow moving bulk
431	Hazardous item storage
442	Sonobuoys
444	Not ready for issue (NRFI) repairables
512	Black iron pipe/ aluminum sheet
513	All other metal items
522	Nuclear submarine piping and metals, boiler tubing
531	Lumber storage
543 544	NRFI repairables storage
600	Steel plate, gun barrels, large propellers
700	Bottled gases
711	Paint/small POL
724 731 733	Large, slow moving bulk items
742	Nuclear weapons spares
821	Controlled submarine repair parts

With the exclusion of the aforementioned warehouses, the remaining 14 warehouses contained 41,847 NSN's or 44.8% of the line items stored in the bulk warehouses. The FC10 program was run over the weekend of 12 March 1977 and identified 3,649 NSN's which had experienced greater than 51 demands in the period under review. This represented 3.9% of the total NSN's stored in the bulk warehouses and 8.7% of the NSN's stored in the 14 warehouses scanned by the FC10 program. These 3,649 NSN's accounted for 493,586 demands during the period of review, an average of 2683 per week, or 558 demands per working day. (250 working days per year.)

The FC10 program had last been run in April, 1976, as a means of determining which items should be considered as fast-moving and restowed in a FAST warehouse area. The data from this run covered a period of 137.5 weeks from 23 August 1973 until 14 April 1976. The run differed from the March, 1977, run, in that no parameter was established to exclude any NSN's because of lack of demand. All records for items located in the selected warehouses were included in the report. A synopsis of the summary statistics is provided in Table 4.

The FC10 report run in March, 1977, was arranged by warehouse and location within each warehouse. The NSN, unit of issue and demand frequency for the period was also contained in the report. Additional output consisted of a deck of IBM cards in the sequence of the report. These were subsequently sorted in

TABLE 4.

APRIL 1976 DEMAND ANALYSIS BY FREQUENCY LOCATION REPORT

BLDG.	TOTAL NO. OF NSN'S	NO. OF NSN'S WITH DEMAND >51	TOTAL NO. L/I DEMANDS	NO. OF L/I DEMANDS FOR NSN'S >51
122	4,838	541	101,825	62,775
221	1,112	28	5,141	2,790
222	3,302	31	11,920	2,749
342	3,200	349	60,149	41,405
343	2,893	355	62,136	42,135
344	1,756	249	39,499	28,618
443	1,107	234	45,711	37,172
541	2,670	54	12,194	4,478
542	2,921	67	15,339	5,765
543	1,494	2	2,447	209
722	3,522	6	4,363	462
724	1,701	47	9,557	5,603
731	2,180	63	15,033	6,677
732	2,666	59	18,768	6,168
734	3,850	766	141,837	104,273
741	2,807	33	10,107	2,923
Totals	42,019	2,884 (6.9%)	556,026	354,202 (63.7%)

354,202 demands ÷ 137.5 weeks in period = 2,576 demands/week.

descending order of frequency of demand by warehouse location. These 3,649 NSN's were then stratified by frequency of demand with a distribution that appeared as follows:

Frequency of Demand Range	Number of NSN's	Cumulative Total
51 - 91	1745	1745
92 - 138	855	2600
139 - 183	405	3005
184	644	3649

At this time, due to the availability of two storekeepers on two-week active duty for training orders, it was decided to collect data on the physical characteristics of the NSN's in the sample. A stamp was utilized to prepare the cards for collecting the required data. An example of the sample card appears as Exhibit 15.

As a result of the small number of NSN's experiencing a frequency of demand of at least one per week (184), it was decided to collect data from all 644 NSN's and to conduct a random sample of the remaining 1260 that experienced at least one demand every two weeks (92) up to one demand every week (184). This resulted in a total sample of 816 items out of a population of 1904. The breakdown of the 816 items is as follows:

Category	No. of NSN's
No material found in the location	143
Material capable of being stored in a bin (less than 35 pounds and 1.1 cu. ft.)	52
Material located in the clothing bins	53
Material oversized for the pallet	31
Located in a chemical section of the warehouse	2
Qualified for bulk storage in modernized warehousing system	535

EXHIBIT 15.

FREQUENCY OF DEMAND CARD USED

TO COLLECT CHARACTERISTICS DATA

4210-00-253-3364 A 122013149 136

WT-UNIT PACK ______________

CUBE-UNIT PACK ______________

HT OF PALLET ______________

PKG PER PALLET ______________

TOTAL NO. OF PALLETS ______________

ITEMS PER UNIT PACK ______________

The 535 NSN's qualifying for bulk storage in a modernized warehousing system further broke down into 409 with 185 or more demands for the period under review and 126 with 184 or fewer demands for the period.

The raw data was then sight-verified to correct any obvious errors or omissions, keypunched, and run through a local computer program to compute basic statistics. The results of this run are contained in Table 5.

The FC10 program was run again during the week of 8 April 1977 for the FAST study being conducted by Mr. A. Webster. Additional warehouses to those surveyed by the March FC10 run were included. The additional warehouses with the number of line items that experienced 51 or more demands and the total number of demands is shown in Table 6.

Issues were related to demands received as a function of net availability. If NSC Oakland had a MSIR for an item, it could receive a demand even though it did not have any material on hand from which to make an issue. The NAVSUP goal for net availability was 85% and NSC Oakland had averaged that in FY76 and 197T. Although net availability had dropped to 81.7% in February, it was considered reasonable to expect that on the average, 85% of the demands received would eventuate in issues made. The warehouse refusal rate, a measure of imbalance between stock records and materials on-hand, had averaged less than 1% since FY76 and was not considered a significant factor.[1]

[1]Statistics provided by NSC Oakland Management Information Center, Code 42.1 for February, FY1977.

TABLE 5.

STATISTICAL ANALYSIS OF BULK INVENTORY SAMPLE DATA

	Mean	Std. Deviation	Range
Items experiencing 184 or more demands for the period			
Wt. of unit pack (lbs.)	94	255	1 -3290
Cube of unit pack (cu.ft.)	4.3	3.8	.2-45.9
Height of pallet (ft.)	3.5	1	2 -5
Pkgs per pallet	22	41	1 -455
Total no. of pallets	5.8	9.9	1 -100
Items per unit pack	46	138	1 -1600
Total wt. per pallet (lbs.)	716	694	5 -4665
Number of demands	320	151	184 -970
Items experiencing 92-183 demands for the period			
Wt. of unit pack (lbs.)	47	60	6 -500
Cube of unit pack (cu.ft.)	2.8	2.9	.2-17.6
Height of pallet (ft.)	3.3	1	2 -5
Pkgs per pallet	12	11	1 -56
Total no. of pallets	3	5.4	1 -41
Items per unit pack	74	154	1 -1000
Total wt. per pallet (lbs)	458	664	6 -5600
Number of demands	120	25	92 -183
All items experiencing 92 or more demands for the period			
Wt. of unit pack (lbs)	85.4	232	1 -3290
Cube of unit pack (cu.ft.)	3.6	3.4	.2-45.9
Height of pallet (ft.)	3.5	1	2 -5
Pkgs. per pallet	20	38	1 -455
Total no. of pallet	5.3	9.3	1 -100
Items per unit pack	52	142	1 -1600
Total wt. per pallet (lbs)	666.6	695.5	5 -5600
Number of demands	281.6	157	92 -970

TABLE 6.

SUMMARY OF STATISTICS FROM FC10

PROGRAM RUN IN APRIL, 1977

BLDG.	TOTAL NO. OF NSN's	NO. OF NSN's WITH DEMAND > 51	TOTAL NO. L/I DEMANDS	NO. OF L/I DEMANDS FOR NSN's > 51
310	10,073	46	19,047	3,645
422	2,117	15	11,818	8,533
442	465	77	9,004	4,608
522	3,422	85	18,859	8,667
543	1,275	11	3,102	849
544	4,648	33	16,046	3,774
724	1,564	72	14,595	9,534
731	402	16	4,279	2,332
733	953	63	11,864	7,994
Totals	24,919	418 (1.6%)	108,614	49,936 (46%)

49,936 demands ÷ 188 weeks in data collection period = 265 demands/week.

VI. REVIEW OF CURRENT STATE-OF-THE-ART MATERIAL HANDLING TECHNOLOGY IN BULK MATERIAL WAREHOUSES

Material processing and storage systems can be broadly classified as "man to material" or "material to man." The "man to material" system used the conventional approach of the man traveling to and from a fixed storage location to perform his work functions. In the "material to man" approach, the worker remained stationary and a device was utilized to move material from a fixed storage location to the work station and thence back to the storage location. Exhibit 16 shows a relationship between the two basic systems and the available equipment types.

The technological advances in "man to material" systems evolved from the historical applications which had used conventional wide-aisle forklifts to move items from fixed storage locations. These conventional or counterbalanced forklift trucks, which carried the pallet straight out in front of the machine on permanently aligned forks, had to turn on right angles in order to move the material in or out of storage. These machines required wide aisles of 10 to 14 feet to access material. As the narrow-aisle technology was developed, several new classes of equipment emerged. The first of these improvements was the narrow aisle reach truck in which the load was carried between the front outrigger wheels and the drive wheels to minimize the need for counterbalancing. These machines normally had a fork extension capability through the use of either a moving mast or a pantograph device which would reach

EXHIBIT 16.

FUNCTIONAL CLASSIFICATION OF PALLET STORAGE MATERIAL HANDLING SYSTEMS

Pallet Storage System

- Equipment type (Storage related)
  - Wheeled Vehicle
    - Counterbalance Forklift Truck
    - Reach Truck
    - Side Reach Truck
    - Sideloader
    - Turret Truck
  - Captive Aisle
    - Stacker Crane
- Handling Technique
  - Man to Material
    - Counterbalance Forklift Truck
    - Reach Truck
    - Side Reach Truck
    - Sideloader
    - Turret Truck
    - Stacker Crane
  - Material to Man
    - Stacker Crane

out beyond the outrigger wheels to position the pallet in racks or on the floor. These machines performed in the same manner as the counterbalanced machines when the forks were extended. They operated in a narrower aisle (usually 7 to 8-1/2 feet) and could make turns in closer quarters because they could retract the pallet to a position within the wheelbase. Exhibit 17 is an example of a reach truck.[1]

The next step in the refinement of the narrow-aisle technology was machines that operated on one side of the aisle and placed the load laterally, across the travel direction of the machine. These machines came in a variety of designs. Some traveled longitudinally in the aisle with permanently located masts equipped with reach devices to move the forks out from the side. Some of these machines had moving masts which added to the extension capability and permitted double depth placement of loads. (See Exhibit 18.) Other configurations had a rotating or swing mast which could reach out to the side (Exhibit 19). The turret type machines (Exhibit 20) could swing their forks through 180 degrees and could load pallets from either side of the machine. These units varied in their aisle requirements and in their flexibility but generally operated in aisle widths of 50 to 84 inches and with clearances only slightly larger than the size of the pallet itself.

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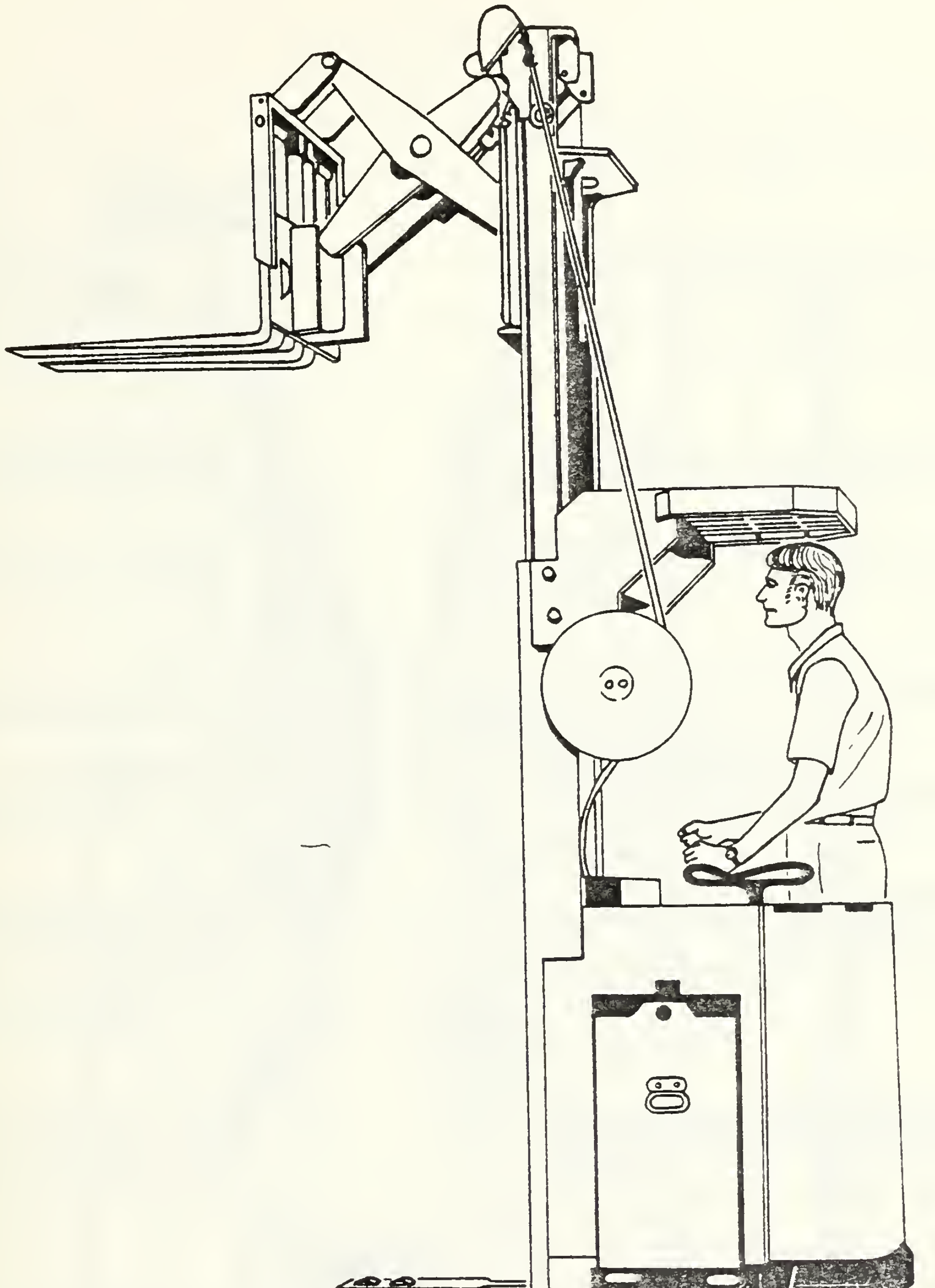
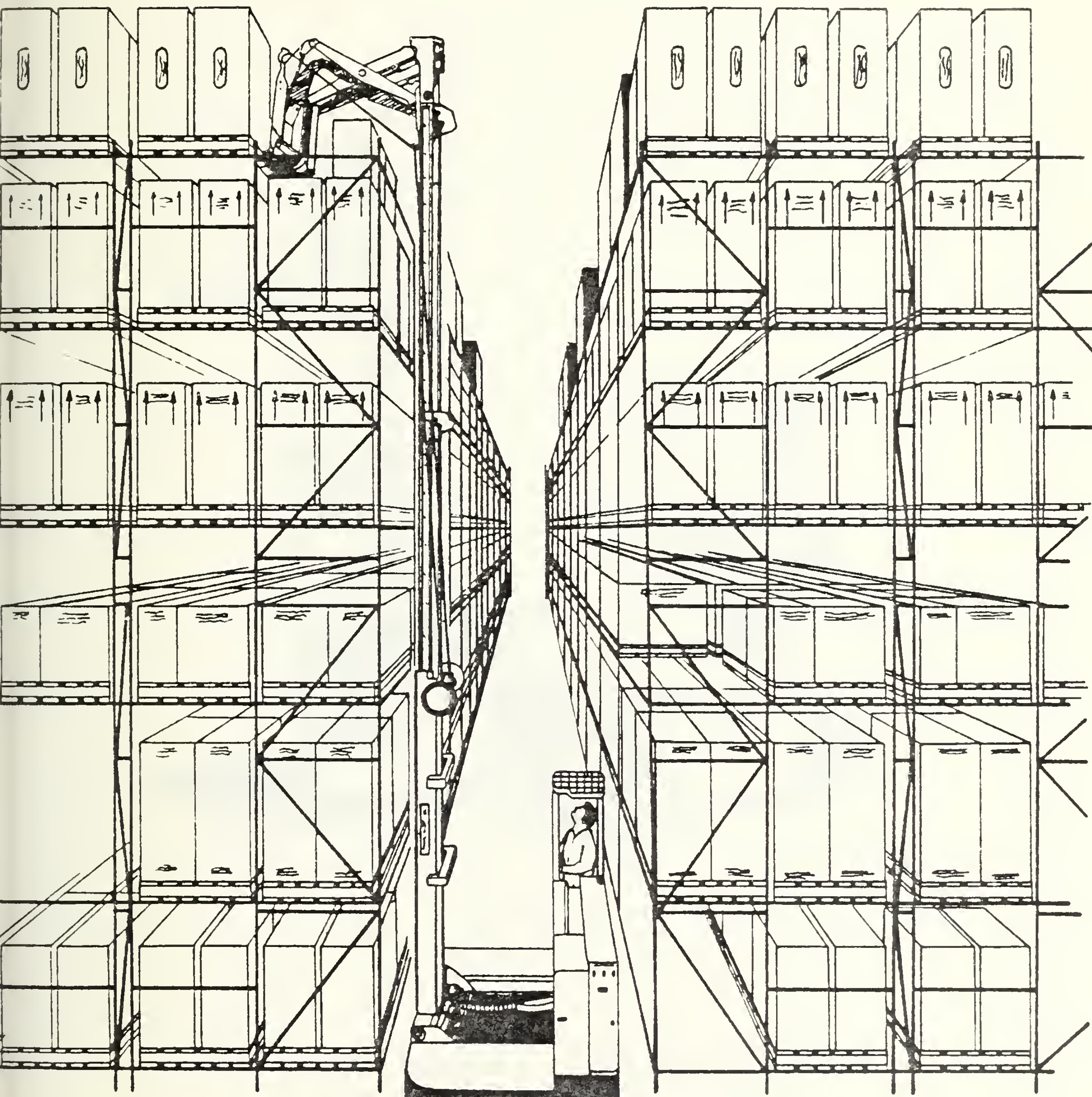
[1]All illustrations of material handling equipment have been reproduced from the March 1977 draft copy of the NAVSUP Publication 529.

EXHIBIT 17.



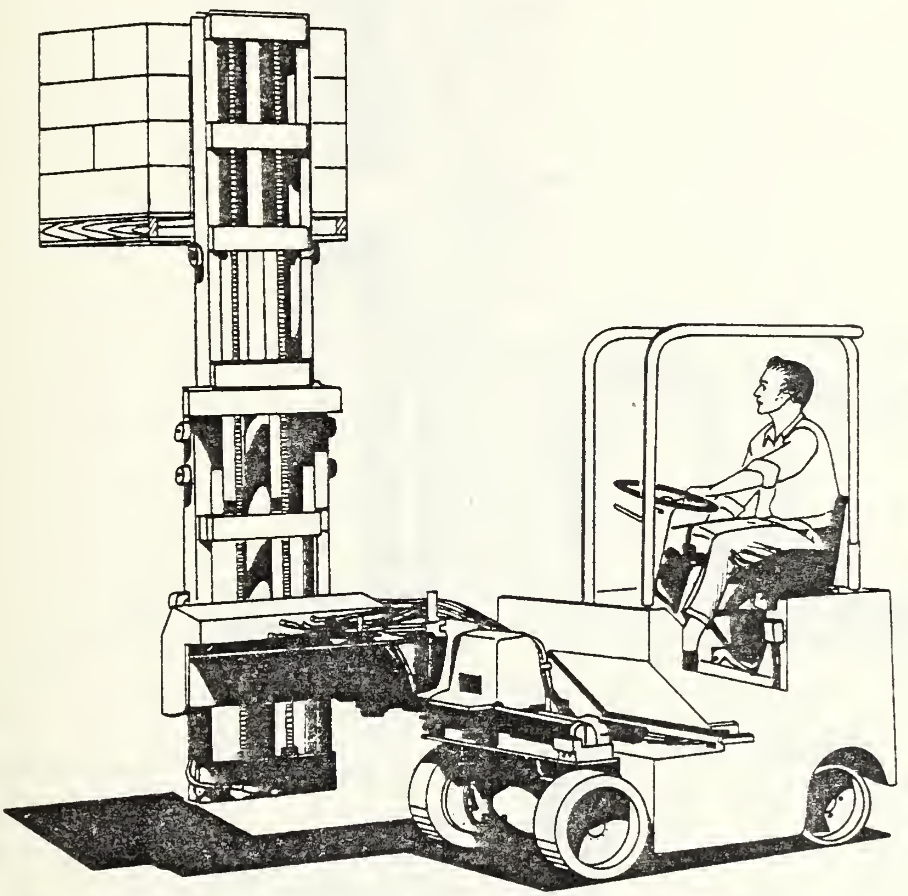
TYPICAL
REACH TRUCK

EXHIBIT 18.



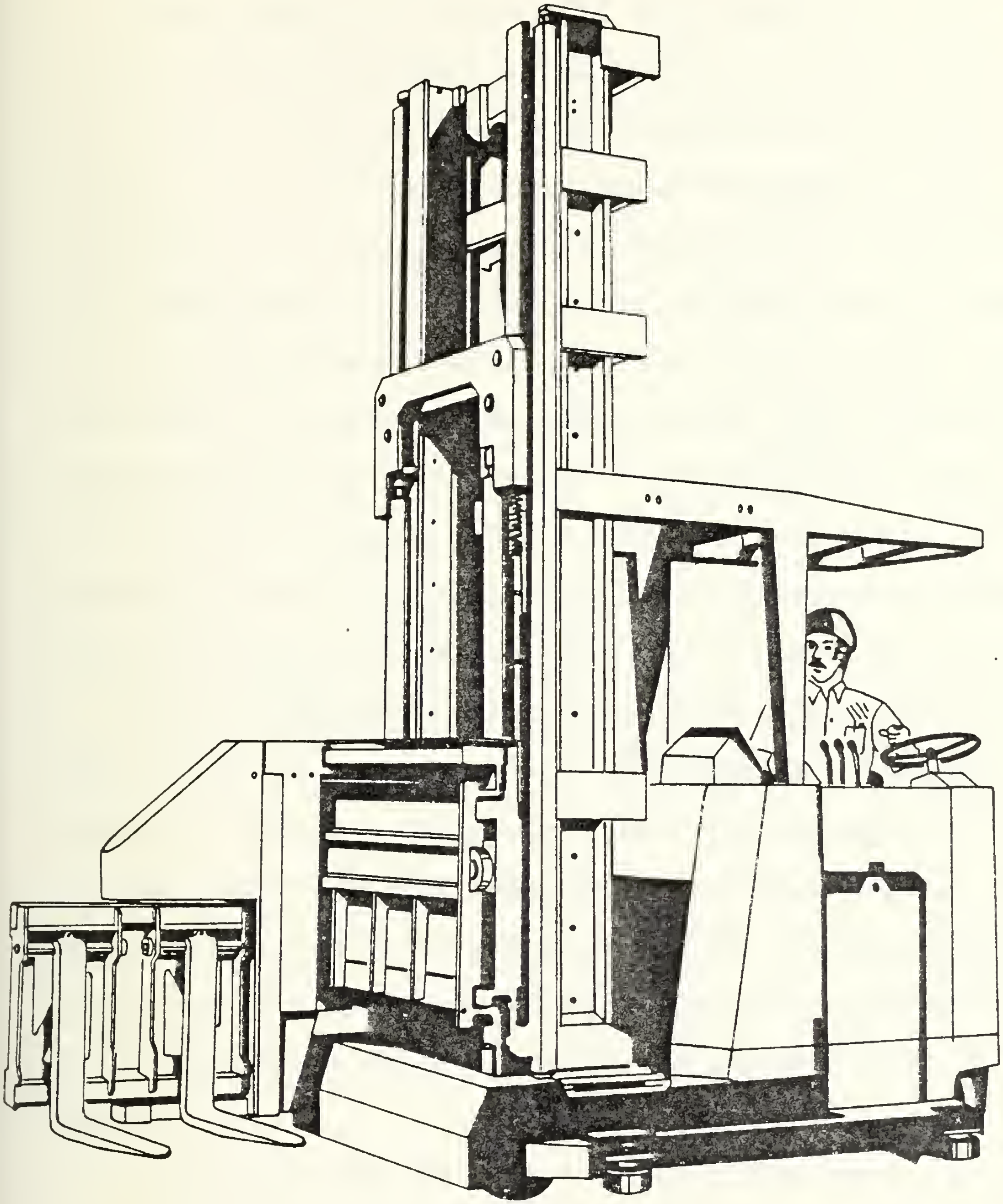
TYPICAL
DOUBLE REACH
SIDELOADER FORK TRUCK

EXHIBIT 19.



SWING MAST LIFT TRUCK
(RACK STORAGE NON-GUIDED AISLES)

EXHIBIT 20.



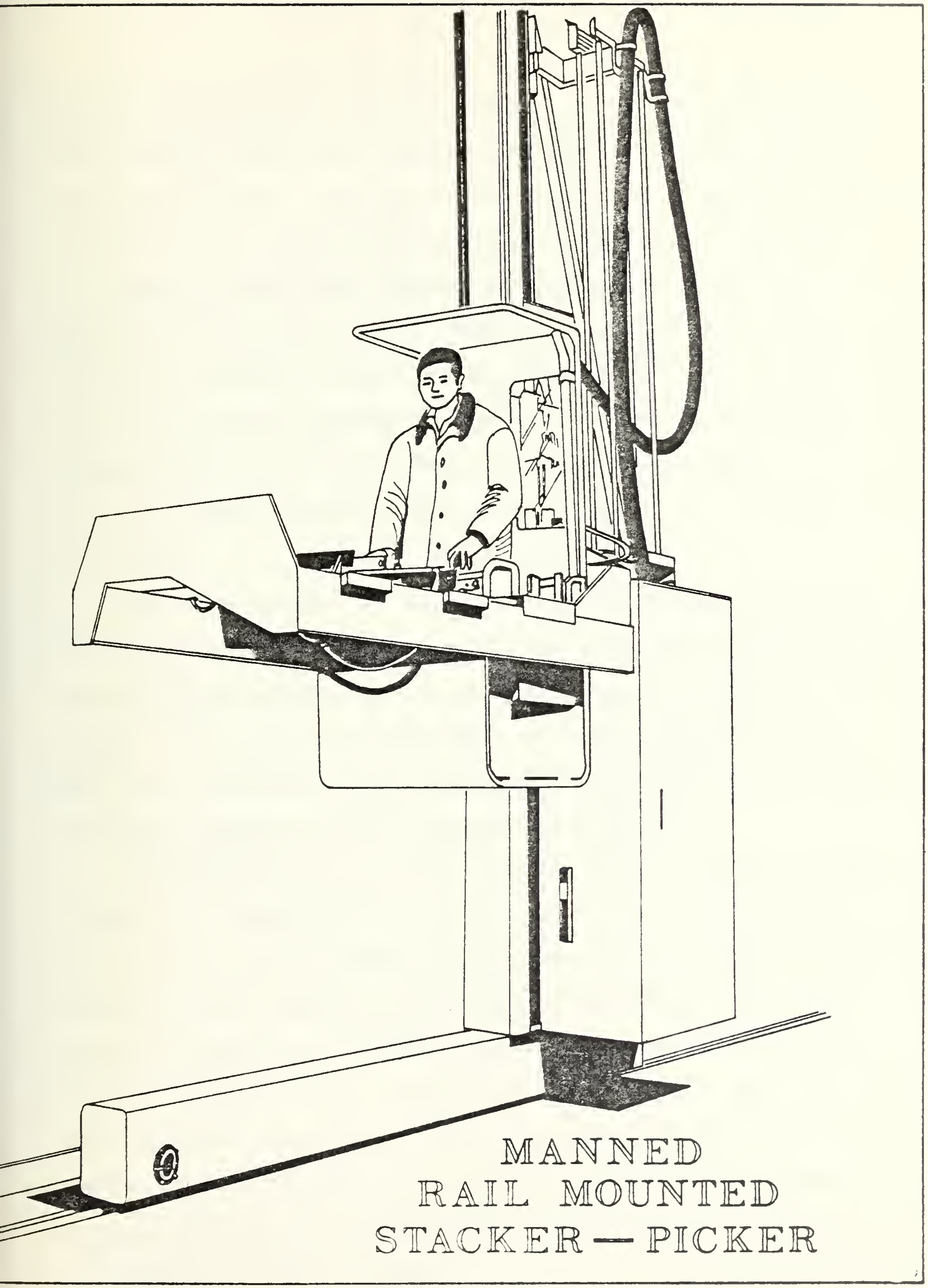
TYPICAL
SWING REACH TRUCK

These close tolerances were permitted by the advancements in control systems which freed the warehouseman from the difficult task of guiding the vehicle through the narrow warehouse aisles. The earliest systems employed bumpers at the top and bottom of the racks and wheels on outriggers on the tractors. The warehouseman had to guide the equipment when it was outside of the aisles, but inside the aisles, the equipment kept itself centered and freed the warehouseman for other operations. Later systems employed a sensing device on the vehicle which followed an energized guidance path, embedded in the floor. The vehicle, moving horizontally and vertically simultaneously could then be automatically guided to the proper storage location.

Yet another type of man-to-material system was the manned rail mounted stacker-picker. These devices could operate to heights in excess of 60 feet, move with high speed (75 feet per minute vertically, 700 feet per minute horizontally) and could be either manual or computer controlled. They normally rode on rails and could be equipped to make aisle transfers to serve multiple storage aisles. Exhibit 21 is an example of such a unit.

Currently, systems were available from simply guided to automatically controlled stock-picking vehicles. The automatic controlled system selected the vehicle to perform a specific transaction, determined the optimum travel path, drove the vehicle to the location, and displayed on a cathode ray tube (CRT) screen on the vehicle the specific operation to be performed.

EXHIBIT 21.



After completing the operation at the location, the warehouseman notified the control system and the vehicle was guided to the next location. Similar to automatically controlled stock-picking vehicles were systems which allowed the warehouseman to manually control the vehicle by keying in the location or feeding in a location card. These manually controlled systems operated similarly to the automatically controlled system, but required a lower investment because there was no requirement for sophisticated computer hardware and software packages. In the 1977 environment these vehicles were limited to a vertical range of 40 feet.

The early concept of "material to man" systems consisted of issuing items from locations using the flow rack principle which automatically moved items on conveyor from live storage conveyor lines. The potential utilization of this type of "material to man" system existed where items had a consistently high activity, standard package size and standard issue quantity.

The development of Automated Storage and Retrieval Systems (ASRS) which operated on the principle of transporting the entire storage module and contents to the man have wider applications than the material to man system mentioned above. The usual configuration of ASRS consisted of a microprocessor controlled retrieval unit, affixed to rails on the floor or on the rack structure, which traveled in an aisle to store or retrieve pallet storage receptacles. The storage racks were generally designed and installed as components of the system. Exhibit 22 is a schematic of such a system.

Automatic Pallet Handling
Typical System

oods in from production	3. Goods in from supplier	5. Pallet check device	7. Transfer device (load)
uffer section	4. Turntable	6. Handling in conveyor	8. Stacker P & D station

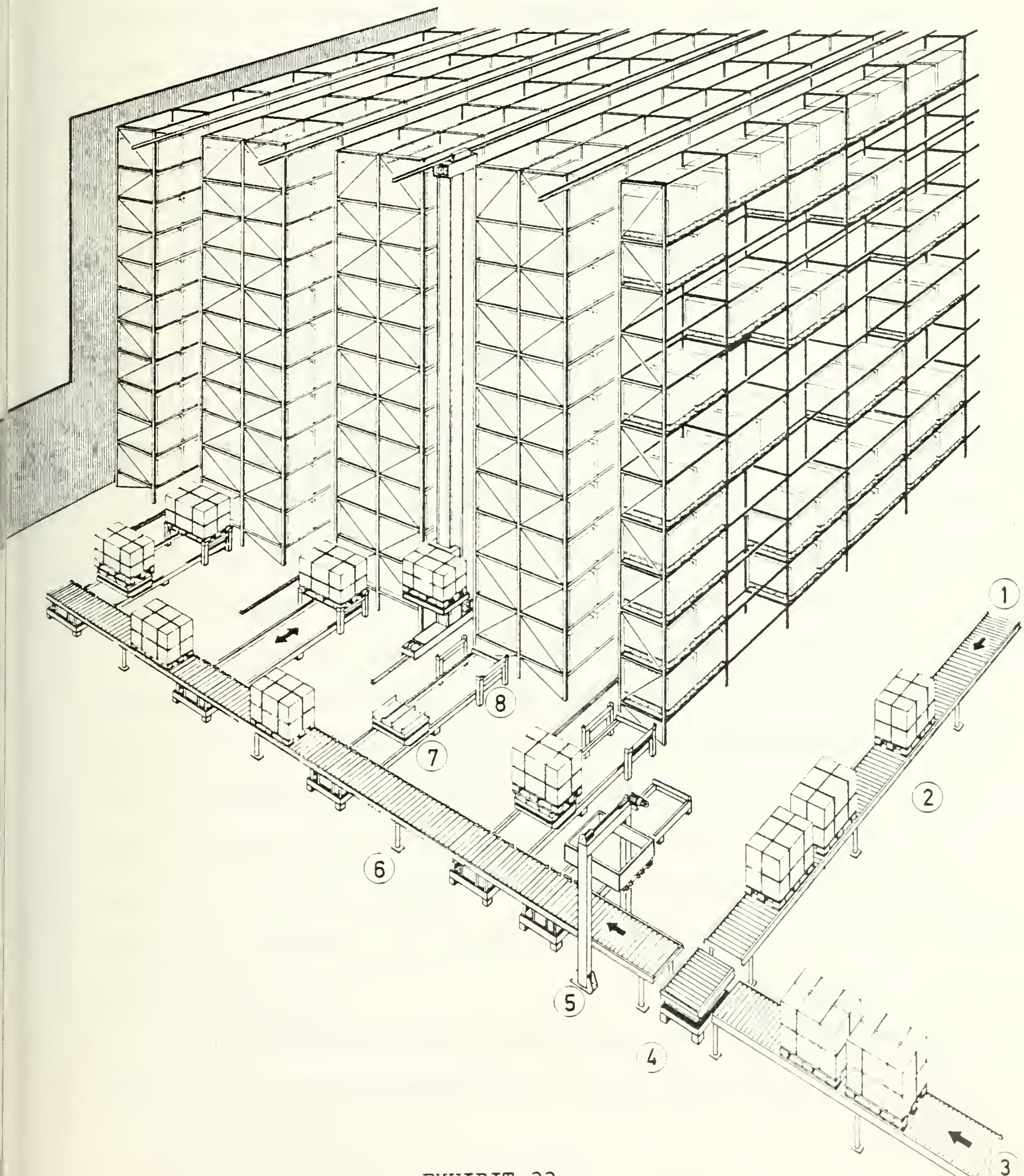


EXHIBIT 22.

To perform a storage operation, upon a command generated manually or by computer, the unit moved to the appropriate location, retrieved the storage receptacle and transported it to a service area where the warehouseman performed his required tasks. Upon completion of the tasks, the warehouseman notified the control center and the unit returned the storage receptacle to the appropriate location.

The guidance system in the stacker-retrieval unit was equipped with numerous positioning efficiencies to maximize throughput capabilities while moving horizontally and vertically simultaneously. The control system eliminated the need for search operations so that throughput rates were dependent only upon the dynamics of the stacker-retrieval unit storage modules. Available control systems varied in their complexity from manually-actuated controllers based on location, to mini-computer driven systems oriented to stock numbers of the material.

Generally, two methods of handling the pallet load of material were available, either by conventional forks or by a shuttle table. The fork arrangement had characteristics similar to conventional pallet trucks and stored the pallet on beams fore and aft. This method had limitations as the beams required to support the pallets added to the cost of the rack structure, raised the overall rack height, and slightly reduced storage capacity.

In the shuttle table arrangement, the pallet was handled from below and was supported by side rails. Since beams were

not used, clearance between pallets could be reduced, lowering the overall rack height and increasing the storage capacity of the system. Since entry forks were not used, the pallet could be oriented in either direction. However, since the pallet was supported on the sides, handling problems could be encountered when mixing different types of pallets.

The automated storage/retrieval systems could be broadly grouped into three categories based on the degree of sophistication involved. The first category, a man-ride system, utilized a manned vehicle or manually positioned storage/retrieval machine, non-precision racks and an in-rack sprinkler system for fire protection. The next category was a semi-automatic system which had storage retrieval machines with automatic positioning and remote control consoles. This type of system required a very precise rack erected to extremely tight tolerances. It had a precision floor track to assure accurate positioning of the storage/retrieval machines and contained an in-rack sprinkler system. The most sophisticated category was a computer controlled system. This system had more than one automatic storage/retrieval machine, precision racks and floor tracks, an in-rack sprinkler system, and an integrated conveyor system for receiving, order picking, and output of full pallet loads. It included a computer system which controlled the operation and maintained an inventory record.

The degree of sophistication determined the cost of a system. As a general rule the higher the degree of sophistication, the

better the system performance would be, up to a limit. System performance was generally measured by throughput - the number of loads per hour the system could simultaneously input (receive and store) and output (retrieve and ship), and by accountability - the ability to keep track of loads going into the system, while they were in storage, and while they were being output or removed from the system.

Appendices H through K detail the cost and performance characteristics of several equipment types that would be suitable for modernizing the NSC Oakland bulk storage material handling function.

VII. THE DILEMMA OF MODERNIZATION

The bulk storage operation at NSC Oakland was highly labor intensive and widely dispersed throughout the base. Productivity rates for issues and receipts, although high when compared to other activities, were very low when compared to binnable rates. The workforce primarily consisted of long service employees, many of whom were eligible to retire within a few years. Labor rates were escalating every year, with no relief in sight. It was almost a certainty that future reduction-in-force actions would further reduce the manpower available to conduct operations in the storage branch. The material handling equipment in use in the bulk storage branch was not current state-of-the-art technology and was becoming increasingly more expensive to operate and maintain. The facilities themselves were all over thirty years old and with three exceptions not conducive to modernization.

The maintenance and utility costs for these buildings were increasing each year.

Although the number of issues in the center had been steadily decreasing over the last several years, it was anticipated that the workload in the bulk issue area would stabilize as repair philosophies shifted from component repair to repair by replacement of major assemblies. This would almost certainly entail more work for the repairable item work centers.

Modernization of the bulk storage material facilities could certainly alleviate many of the foregoing problems.

Modernization had been planned by the ROACH report, as part of an overall master plan. Such a plan would not be expected to reach fruition much before 1985 with the current funding constraints on military construction. Therefore, the problem was one of a short-term nature - how best to cope with the environment which promised from all indications to be increasingly harsh on the bulk storage operation if the status quo was maintained.

Any modernization effort, to be successful, had to rely on the availability of funds. Certain limited funds were available, but only to projects demonstrating an extremely short pay-back period. The basic question to be answered was, "could NSC Oakland propose a material handling system modernization alternative that would increase efficiency and effectiveness, while demonstrating a sufficiently high savings/investment ratio to be considered for funding by NAVSUP?"

VIII. CONCLUSIONS/RECOMMENDATIONS

A. CONCLUSION 1 - Live Floor loading for an automated high-rise storage retrieval system does not have to be 1800 pounds per square foot (PSF).

The derivation of this requirement is not apparent from either the data or discussions with the individuals involved. In Appendix E, reference was made to large rolls of paper that weighed 1,800 pounds, but this could not be translated to 1,800 psf. In actuality, if the maximum weight of the pallet and its load is 2000 pounds and the racks are seven tiers high, the actual live floor load is 496.77 psf, computed as follows:

2000	lbs/Pallet Load			
x 7	Tiers			
14000	lbs		14,000	
x .10	%[1]		+1,400	
1400	lbs		15,400	lbs

15,400 lbs ÷ 31 SQ FT/PALLET STACK (From Appendix K) = 496.77 psf. This is barely within the stated limits of the floor, but could be reduced by using a lighter load factor or less tiers.

The calculation is designed to point out the fact that a high-rise system could be installed in Building 422 without the investment of 1.2 million dollars to install a floor with an 1800 psf live load factor. Thus, without the requirement to commit MILCON dollars, the high-rise is still a viable alternative.

B. CONCLUSION 2 - The economically justifiable system for NSC Oakland would be less than the 10,000 openings proposed earlier.

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[1] Rack manufacturers stated that the weight of the racks and crane amount to 10% of the weight of the load being supported.

Apparently the figure of 10,000 openings was a result of the determination that any bulk item experiencing a frequency of demand of 18.5 or more per year (Appendix B) was considered fast-moving and the demand analysis by frequency location report which contained approximately 5000 NSN's in this category. The mode of 2 pallets per stock number was obtained from the first sampling exercise, but the data was not available to substantiate this figure. It was anticipated that the demand analysis by frequency location report run in March, 1977, would indicate the approximate number of line items that would qualify for inclusion in a modernized warehouse system, using the criteria of slightly more than 1 demand per month (51 demands for the period of review). By physical distribution industry standards, 1 demand per month is far from qualifying the item as "fast-moving," but by Navy management standards it is sufficient.

The FC10 run in March, 1977, contained 3,649 line items which had experienced 51 demands for the period. From the sample of the physical characteristics of the material, page 51, it was discovered that 4.6% of the items (31/673) were oversized for the pallet, 7.7% of the items (52/673) were capable of being stored in the bin complex, and that 7.7% (53/673) were stored in the clothing bin area. Applying these percentages to the total population, it could be estimated that 730 items would be excluded from the system for the above three reasons. This left a total of 2,919 line items that would qualify as fast moving.

From table 5, it can be seen that the sample mean number of pallets per NSN sampled was 5.3 with a standard deviation of

9.3 pallets. Assuming normality, computing a 95% confidence interval for the population mean number of pallets per NSN yields [4.51, 6.09].[1] To test the hypothesis that the population mean would be less than 5 pallet loads per NSN at the 95% level of significance, the value of the test statistic was computed using the formula $z = \frac{\sqrt{n}\,(\bar{x}-\mu o)}{\sigma}$ where $\mu o = 5$. This yielded a value of .746 which was less than the 95% Z value of 1.64. The conclusion is that based on the sample, the bulk material population would most likely (with 95% confidence) have an average of about 5 pallets of material per line item. This statistic is based on the assumption that the quantities present in the warehouse when the sample was conducted represented average on-hand quantities and not abnormally low stock levels.

The average of 5 pallets per NSN could be misleading, however, when the distribution of the sample was viewed as in Exhibit 23.

From this distribution, the modal number of pallets per NSN is 1, and this amounted to 41.1% of the items sampled. If the items with ten or more pallets per NSN are excluded from the system, this would reduce the number of items by 14.1%, but the mean number of pallets per NSN from 5.3 to 2.7. Based on this observation, an additional 515 items (3,649 X 14.1%) would be excluded from the system because the items contained more than 9 pallets per NSN.

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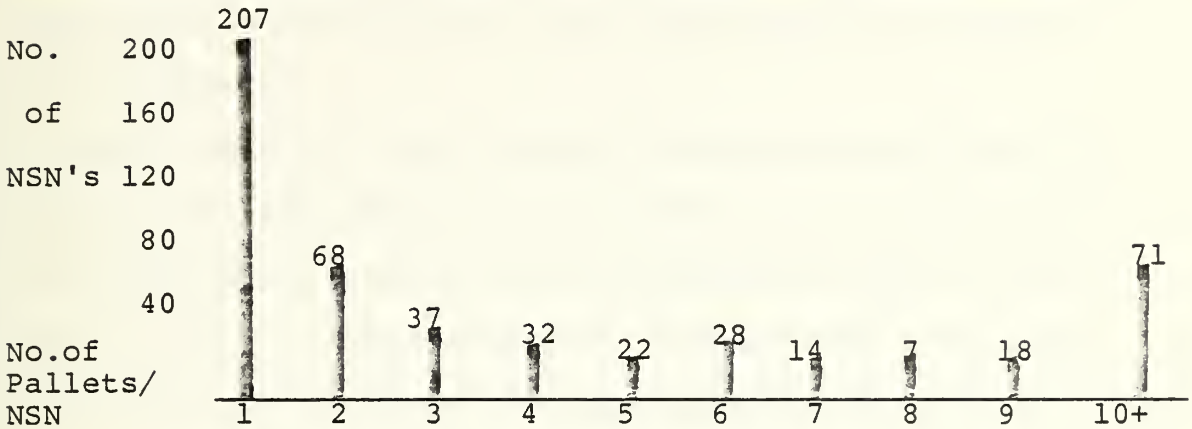
[1]Where $[\ell,\mu] = \bar{x} \pm Z1 - \alpha/2 \frac{\sigma}{\sqrt{n}}$, $\bar{x} = 5.3$, $1-\alpha/2 = 1.96$, $\sigma=9.3$ and $n = 535$.

EXHIBIT 23

DISTRIBUTION OF NUMBER OF PALLETS/NSN FROM SAMPLE



Individual %	41.1	13.5	7.3	6.3	4.4	5.6	2.7	1.4	3.6	14.1
Cumulative %	41.1	54.6	61.9	68.2	72.6	78.2	80.9	82.3	85.9	100.
Total No. of Pallets	207	136	101	128	110	168	98	56	162	1554
% of total	7.6	5.0	3.7	4.7	4.0	6.2	3.6	2.0	6.0	57.2
Cumulative %of total	7.6	12.6	16.3	21.	25.	31.2	34.8	36.8	42.8	100.

The total capacity of the system should therefore be approximately 2,405 x 2.7 or 6,494 openings. For the sake of simplicity in computations, this figure could be rounded to 6,500 openings.

The weight and height of the pallet load could be computed in the same manner as the number of pallets per NSN. A 95% confidence interval for the population mean weight was [607.6, 725.5]. The probability that a pallet load would weigh less than 1,800 pounds was almost 95%.[1] Using the same computations, the height of the load would be less than 5.5 feet 95% of the time.

Therefore a system should be acquired to handle 6,500 pallet loads of material 1,800 pounds in weight and 5.5 feet high.

C. <u>CONCLUSION 3</u> - The transaction rate for a proposed high-rise storage/retrieval system would be approximately half of the rate stated in the earlier NSC Oakland proposal.

From page 48, the 3,649 NSN's accounted for an average of 558 demands per working day.[2] By excluding the four categories of items mentioned earlier from the proposed system, the number of NSN's was reduced by 34.1%. Since demand was random throughout the sample, it could be assumed that a 34.1% reduction in NSN's would lead to a commensurate reduction in demands. Based

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[1] $\Pr(X\ 1800) = \Phi\left(\frac{1800-666.6}{695.5}\right) = \Phi\ 1.63 = .948\%$

[2] 184 weeks ÷ 52 weeks/yr. = 3.538 years X 250 working days/year = 884.5 working days in period of review. 493,586 demands ÷ 884.5 working days = 558 demands/working day.

on this assumption, the number of demands per working day for the 2,405 items in the system would be 368. Based on the 85% net availability figures, this equates to 313 issues per day. With a ratio of 3 issues to 1 receipt, this would assume 104 receipts per day, for a total of 417 issue and receipt transactions per working day. When the data from table 6 was included, an additional 306 NSN's requiring 826 openings were added to the system. (Table 6 figures minus 26.7% for exclusions mentioned earlier.) These additional NSN's accounted for an average of 35 issues and 12 receipts per working day.[1] From table 3, it can be seen that functions other than issues and receipts account for 23% of the workload. As a function of issues and receipts, this amounts to approximately 44% or 204 transactions per day. The total number of transactions per day for the system would then be 668. This would break down into 552 "in and out" transactions and 116 "in" transactions, assuming issues and other maintenance functions to require in and out movement and receipts to require in movement only.

The composite picture for the system now would appear as requiring 7,320 openings(6,494 + 836) to support loads of 1,800 pounds and 5.5 ft. in height, with 668 transactions per day.

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[1] 36,753 demands X .85 net availability + 31,240 issues, 188 weeks ÷ 52 = 3.615 yrs. X 250 working days/year + 903.8 working days. 31,240 issues ÷ 903.8 working days = 35 issues/working day. Receipts were in the ratio of 1:3 issues, hence 12 receipts.

D. CONCLUSION 4 - Using the criteria of the NAVSUP PUB. 529, the least cost alternative was a system using 5 high storage racks and turret trucks.

Exhibit 24 is a table from the NAVSUP publication 529 which gave a gross ranking of systems by cost based on a Transaction/ Inventory (T/I) ratio. Using this method, a T/I ratio of .0913 would be computed for the proposed system at NSC Oakland. (668/ 7,320). From Exhibit 11, only three buildings appeared to have the ceiling height necessary to accommodate storage exceeding 4 pallets high -- 422, 522 and 531. Using the building height ranges of 30 feet for building 531 and 40 feet and over for buildings 422 and 522, with a T/I ratio of .0913, the system with the least cost appeared to be the one utilizing the turret truck. The sideloader truck appeared to be second in the 30 foot height range with the stacker crane second in the 40 foot and over range. The ranking of systems as stated in the NAVSUP 529 was verified by the calculations contained in Exhibit 25. The turret truck with 4 high storage levels at $107,811 annual system operating costs appeared to be the least cost system. It should be noted, however, from the floor plan of building 422 in Appendix G, that 54,000 sq. ft. was the maximum area available for installation of a bulk material handling system under one roof. Therefore, the turret truck system with a 4 high storage racks at 62,220 square feet was clearly larger than the available capacity of any one warehouse. The next lowest cost system was a turret truck with 5 high storage racks at $109,812 annual system operating costs.

Exhibit 24

PRELIMINARY SYSTEM SELECTION CRITERIA PALLET STORAGE SYSTEMS (Ranked in Order of Increasing Cost)				
	New Construction		Existing Building	
Building Height	T/I Range	System	T/I Range	System
15 feet (2 pallet high storage)	<1.000	2,3,4,5	>0.040 0.034-0.040 <0.034	2,5,4,3 5,2,4,3 5,4,2,3
20 feet (3 pallet high storage)	>0.116 <0.116	2,1,3,4,5 1,2,3,4,5	>0.035 0.022-0.035 <0.022	2,5,4,1-3 5,2,4,1-3 5,4,2,1-3
25 feet (4 pallet high storage)	>0.183 <0.183	2,1,3,4,5 1,2,3,4,5	>0.200 0.033-0.200 0.015-0.033 <0.015	2,5,1,3,4 2,5,1,4,3 5,2,4,1,3 5,4,2,1,3
30 feet (5 pallet high storage)	All	1,3	All	1,3
35 feet (6 pallet high storage)	All	1,3	All	1,3
40 feet and over (7 - 14 high storage)	>0.216 0.143-0.216 <0.143	6,7,1 6,1,7 1,6,7	>0.224 0.176-0.224 <0.176	6,7,1 6,1,7 1,6,7

System definition:
1. Turret Truck
2. Side Reach Truck
3. Sideloader Truck
4. Reach Truck
5. Counterbalance Truck
6. Stacker Crane - 14 high
7. Stacker Crane - 7 high

This in fact would fit in building 422 or building 531, with room to spare for other peripheral activities. With a 2,000 lb. pallet load, 5 racks high and a 10% loading factor for weight of the racks, a total of 11,000 pounds per pallet stack would be borne by the floor. This amount divided by 34 sq. ft. per pallet stack from Appendix H, would yield a live floor loading of 324 psf., which is within the limits of building 422.

Unfortunately, this type of analysis disregarded the impact of inflation on labor, operations and maintainence costs. When only a modest inflation factor of 6% was introduced into the comparison, the alternatives which were highly dependent upon labor, such as the manned equipment alternatives, became the least attractive in the out years. For this reason, it would be prudent to evaluate the alternatives in a manner that would contain provisions for inflation and discounting cash flows to present values.

The guidance for comparing alternative methods of accomplishing an overall objective within the Naval Supply Systems Command was contained in NAVSUP INSTRUCTION 7000.10A of 29 October 1974. This instruction addressed the relevant facets of conducting an analysis of the costs and benefits of proposed alternatives against the current method of operation and served as the basis for the analysis which follows.

Exhibit 25

Computation of Total Annual System Operating Costs for Alternative Bulk Material Handling Operations.

System	Storage Levels				
Turret Truck	3	4	5	6	7
Area req'd (sq.ft.)[1]	82,716	62,220	49,776	41,724	35,868
Transaction time (min/trans.)	1.41	1.49	1.59	1.70	1.83
Manhours req'd[2] (annual)	4,485	4,740	5,058	5,408	5,821
Machines req'd[3]	2.56	2.70	2.89	3.09	3.33
Building costs (area x .22/sq.ft.)[4]	$ 18,198	$ 13,668	$10,951	$ 9,179	$ 7,891
Annual Storage equipment costs[5]	23,497	23,497	23,497	23,497	23,497
Annual Labor Cost[6]	46,509	49,154	52,451	56,081	60,364
Annual Vehicle operating costs[7]	20,317	21,472	22,913	24,498	26,369
Total annual system operating costs	$108,521	$107,811	$109,812	$113,225	$118,121
Sideloader Truck					
Area req'd (sq.ft.)	94,428	70,272	56,364	46,848	
Transaction time(min/trans)			1.79	1.91	
Manhours req'd (annual)			5,694	6,076	
Machines req'd			3.25	3.47	

[1] From Appendix J. Tabled values multiplied by 7.32.

[2] Manhours required = (transaction time x throughput x number of workdays) ÷ (60 x .875)

[3] Assuming 1,750 m/h = 1 man year.

[4] From page 39.

[5] From Appendix H. ($3.21)

[6] Manhours x $10.37 - From page 4, a composite of 7.34 and 7.69 times 1.38.

[7] Manhours times $4.53 from Appendix H.

Exhibit 25 (con't)

Sideloader Truck (con't)	2	3	5	6	7
Building Costs			$12,400	$10,307	
Annual storage equip cost			23,497	23,497	
Annual labor cost			59,047	63,008	
Annual vehicle operating cost			20,897	22,299	
Total annual system operating costs			$115,841	$119,111	
Stacker Crane					
Area req'd					32,354
Transaction time					1.29
Manhours req'd[8]					954
Machines req'd					2.05(2)
Transfer cars req'd					2.05(2)
Building costs					$ 7,118
Annual storage equip. costs					73,200
Annual labor costs					9,893
Annual machine operating costs					29,000
					$119,211
Counterbalance Truck					
Area req'd	223,260	148,596			
Transaction time	1.67	1.82			
Manhours req'd	5,312	5,789			
Machines req'd	3.0	3.3			
Building costs	49,117	32,691			
Annual Storage equip costs	23,497	23,497			
Annual labor costs	55,085	60,032			
Annual vehicles operating costs	9,402	10,246			
	$137,101	$126,467			

Storage Levels: 5, 6, 7

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[8] See note at bottom of table of Standard Transaction Times for Pallet Handling Systems, Appendix I.

E. <u>CONCLUSION 5</u> - Using the criteria of the NAVSUPINST. 7000.10A, the preferred alternative was a high-rise storage/ retrieval system utilizing unmanned stacker cranes.

In order to compare alternatives against the current method of operation, it was first necessary to allocate personnel and material handling equipment to the material that would be stored in the proposed system. Exhibit 26 shows the percentage of each work center demand that could be attributed to those items that would be candidates for the proposed modernized system. Exhibit 27 shows the number of personnel that would be allocated on a percentage of demand basis to the 2,711 items proposed for the modernized system. Under current methods of operation, 26 personnel would be required to manage the activity of these items, as they are now stored in the warehouses. Exhibit 28 is the same calculation for MHE requirements. These calculations assume proportionality between frequency of demand, issues, receipts, all other functional activities, manpower and MHE requirements. Annex A to Appendix B states that there is only .277 line items difference between slow and fast moving issue rates. This amounts to approximately one minute per issue difference which is not large enough to affect the calculations.

Exhibit 29A contains the total system costs, in present value terms, of managing the 2,711 items proposed for the modernized facility, as they are now stored in the various warehouses. All base year costs were inflated by 6% per year and the stream of

Exhibit 26

Distribution of Workload by Work Center

Work Center[1]	Total No. of L/I Demands	Demands for NSN's with >51 for period	Percent of Demands for NSN's with >51 demands.
Section 1, Unit A	33,832[2]	9,748	28.8
Section 1, Unit B	72,343[3]	45,883	63.4
Section 1, Unit C	156,350	112,533	80.0
Section 1, Unit D	48,271	16,230	33.6
Section 1, Unit E	163,258[4]	117,870	72.2
Section 2, Unit A	-- Excluded from computations due to nature of material stored.		
Section 2, Unit B	137,933[5]	71,959	52.2
Section 2, Unit C	30,677	17,200	56.1
Section 2, Unit D	-- Excluded from computations due to nature of material stored.		

---

[1] From Exhibit 5.

[2] Excludes demands for building 444.

[3] Excludes demands for buildings 131, 144, 243.

[4] Excludes demands for buildings 821, 831, 832.

[5] Excludes demands for building 113.

EXHIBIT 27

Number of Personnel Attributed to Fast-Moving Items Based on Frequency of Demand

Work Center	Number of Personnel Assigned		% of demands for Items >51 for period		Total number of personnel attributed to items >51 demands	
Section 1:						
Unit A	10	x	28.8	=	2.88, say	3
Unit B	6[1]	x	63.4	=	3.80	10
Unit C	12.5[2]	x	80.0	=	10.0	10
Unit D	4[3]	x	33.6	=	1.34	1
Unit E	11[4]	x	72.2	=	7.94	8
Section 2:						
Unit B	13	x	52.2	=	6.79	7
Unit C	8[5]	x	56.1	=	4.49	4
Audit Team	8	x	28.6[6]	=	2.29	2
Total						39

There would be 39 personnel if all items with greater than 51 demands for the period of review were included in the system. However, from earlier calculations, 34.1% of these items, representing a corresponding percentage of demands would be eliminated from consideration for the proposed system. Therefore, the remaining number, 26, would be the number of personnel that should be assigned to the proposed system, based on a percentage of the frequency of demand for those items in the system.

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[1] Excludes 1 person assigned to buildings 131, 141, and 243 for which no demand data was available.

[2] Excludes 1.5 persons assigned to building 442, for which no demand data was available. 442 contains sonobuoys which would not be included in system.

[3] Excludes 8 people assigned to audit team - personnel reduction in this area will be computed separately.

[4] Excludes 3 personnel assigned to buildings 821, 831, 832 which contains materials that would not be included in the proposed system.

[5] Excludes 1 person assigned to building 531 for which no demand data was available.

[6] Computed by taking 313 issues/day x 250 working days and dividing by 274,000 estimated bulk issues for 1977.

Exhibit 28

Number of Pieces of Material Handling Equipment (MHE) Attributed to Fast-Moving Items Based on Frequency of Demand

Work Center	Number of Pieces Assigned		% of Demand for Fast-Moving Items		Number of Pieces of MHE Attributed to Fast-Moving Items	
Section 1:						
Unit A	8	x	28.8	=	2.3, say	2
Unit B	4[1]	x	63.4	=	2.5	3
Unit C	8[2]	x	80.0	=	6.4	6
Unit D	6	x	33.6	=	2.0	2
Unit E	8[3]	x	72.2	=	5.8	6
Section 2:						
Unit B	12	x	52.2	=	6.3	6
Unit C	5[4]	x	56.1	=	2.8	3
Total						28

To equate the 28 pieces of MHE attributed to the fast-moving items to the number of NSN's in the proposed system, a reduction factor of 34.1% should again be introduced. This would result in a reduction to 18 pieces of MHE that should be allocated to the proposed system, based on frequency of demand.

---

[1]Excludes (1) 4,000 lb. and (1) 6,000 lb. forklift assigned to buildings 131, 141, 243, for which no data was available.

[2]Excludes (2) 4,000 lb. forklifts assigned to building 442.

[3]Excludes (1) 6,000 lb. and (2) 4,000 lb. forklifts assigned to buildings 821, 831, 832.

[4]Excludes (1) 6,000 lb. forklift assigned to building 531.

costs were then discounted to present value at 10% as required by NAVSUP INST. 7000.10A of 29 October 1974. The 22 cents per square foot building and utilities cost was taken from the ROACH report. If the 50 cent figure utilized in the NSC Oakland high-rise justification was used, the current method of operation becomes even more unattractive when compared to any high-rise alternative.

This computation assumed that the MHE were already in use, but with an average age of 10.9 years, one piece per year would have to be replaced. This could be a very conservative estimate with 18 pieces of MHE involved.

Exhibit 29B contains the calculations for alternative I, which was a system that would employ 3 turret trucks and 5 level high storage racks. An additional 3 pieces of MHE, 4,000 pound forklifts, would be required to move issues and receipts from the rack area to staging areas and from the receiving area to the racks. The number of personnel was derived from a package picking rate of .15 minute/package (from various tables in section 19 of NAVSUP 529) times an average of 7 loose pieces per L/I (from NSC Oakland high-rise proposal) times 668 transactions per day. This resulted in a requirement for 1.67 men per day. Assuming 3 turret trucks, and 3 forklift operators plus 1.67 order pickers times 24% for supervision and leave equals 9.5 men required or 10 men. This would allow one supervisor, 3 turret truck operators, 3 order pickers, and 3 forklist operators.

Establishing a new system entails rewarehousing costs in relocating the existing material in building 422 to another location, as well as moving the material from the existing locations to the new system. This was computed on a one-in, one-out basis using the standards contained in enclosure (2) to Appendix B.

The MHE operating and maintenance costs were taken as given in the NAVSUP Publication 529, $1,500 per year. This figure would more accurately reflect the expected operating and maintenance costs than the DODMDS data call costs because the tempo of operations would be governed by the transaction rates established by the NAVSUP PUB. 529 and not by current production figures.

Exhibit 29C contains the computation of costs for Alternative II, a system employing 2 stacker cranes with transfer cars, 7 level high storage racks, and the same additional MHE required by Alternative I. The personnel requirements were derived the same as for Alternative I with the exception that 3 turret truck drivers and 1 order picker were not required because of the automated cranes. The crane operators/order pickers can perform stock picking functions while the crane is storing or retrieving another load. Based on the NavSup Pub 529 statistic on page 19-5, it requires .30 minutes/transaction to enter information into the stacker system. This statistic, coupled with the order picking statistic of 1.05 minutes/transaction, yields a personnel requirement for these two functions of 2.147. With only 2 personnel

Exhibit 29A

Computation of System Costs in Present Value Terms

Current Method

System--Counterbalanced Trucks, 2-3 high storage racks. 185,928 sq. ft.[1] 26 personnel, 18 pieces of MHE. Initial Capital Investment - 0.

Annual Operating Costs

Year	Building & Utilities[2]	Labor[3]	MHE[4]	Total
1	$40,904	$560,810	$32,218	$ 633,932
2	$43,358	$598,458	$34,151	$ 671,967
3	$45,526	$630,126	$36,200	$ 711,852
4	$47,802	$667,933	$38,372	$ 754,107
5	$50,192	$708,009	$40,674	$ 798,875
6	$53,204	$750,490	$43,115	$ 846,809
7	$56,396	$795,519	$45,702	$ 897,617
8	$59,779	$843,250	$48,444	$ 951,473
9	$63,366	$893,845	$51,351	$1,008,562
10	$67,168	$947,476	$54,432	$1,069,076

Present value of annual operating costs of current method=

$5,141,152.

Total system costs - present value terms - $5,141,152.

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1 Based on average square footage for 2 and 3 high storage heights.

2 Based on .22/sq. ft.

3 $10.37/hr. x 2080 hours per man year x 26 personnel.

4 Assumes replacement of 1 piece of MHE per year at $16,000, plus 212 hours of operation per piece of MHE per year at $4.25/hour. (from DODMDS data call.)

Exhibit 29B

Computation of System Cost in Present Value Terms

Alternative I

System--Turret Truck, 5 high storage racks, 49,776 sq.ft., 10 personnel,[1] 3 turret trucks, 3 pieces of additional MHE.
Initial capital investment:

3 Turret Trucks at $64,200	=	$192,600
7,320 rack openings at $30.00	=	219,600
Rewarehousing: 14,640 actions[2] x $5.84[3]	=	85,498
Total		$497,698

Annual Operating Costs

Year	Building and Utilities	Labor	MHE[4]	Total
1	$10,950	$215,696	$ 9,000	$ 235,646
2	11,608	228,638	9,540	249,786
3	12,304	242,356	10,112	264,772
4	13,042	256,897	10,719	280,658
5	13,825	272,311	11,363	297,499
6	14,655	288,650	12,044	315,349
7	15,534	305,969	12,767	334,270
8	16,466	324,327	13,533	354,326
9	17,454	343,787	14,345	375,586
10	18,501	364,414	15,205	398,120

Present Value of Annual Operating Costs of Alternative I = $1,913,376.

Total System Costs - Present Value Terms - $2,411,074.

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[1] Assumes 3 Turret Truck drivers, 3 order pickers, 3 fork-lift drivers, 1 supervisor.

[2] Assumes existing material will have to be relocated to make room for new system, material will have to be moved from old location to new system.

[3] Computed from standards in enclosure (2) to Appendix B.

[4] Assumes $1,500 per piece of MHE per year.

Exhibit 29C

Computation of System Cost in Present Value Terms

Alternative II

System--stacker crane, 7 hgih storage racks, 32,354 sq. ft., 6 personnel,[1] 3 pieces of MHE.

Initial Capital Investment:

2 stacker cranes at	$70,000	=	$ 140,000
2 transfer cars at	30,000	=	60,000
7,320 rack openings at $100/opening		=	732,000
Rewarehousing costs		=	85,498
Total			$1,017,498

Annual Operating Costs

Year	Building and Utilities	Labor	MHE[2]	Total
1	$ 7,118	$129,417	$ 13,500	$150,035
2	7,545	137,182	14,310	159,037
3	7,998	145,413	15,169	168,580
4	8,476	154,138	16,079	178,693
5	8,986	163,387	17,043	189,416
6	9,525	173,190	18,066	200,781
7	10,097	183,581	19,150	212,828
8	10,703	194,596	20,299	225,598
9	11,345	206,272	21,517	239,134
10	12,026	218,648	22,808	253,482

Present value of annual operating costs of Alternative II = $1,218,237

Total System Costs - present value terms - $2,235,736.

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[1] Assumes 3 order pickers, 3 forklift operators.

[2] Assumes $3,000 each for stacker cranes and $1,500 each for transfer cars, and fork lifts.

assigned to crane operation/order picking, an additional man hour per day would have to be obtained from the fork lift operator or the supervisor. The additional 1 hour per day does not warrant the inclusion of an additional person in the system. However, with the 24% provision for supervision and leave, the total personnel requirement for this system becomes 6.38. With only 6 personnel assigned, an additional 2-2/3 hours per day would have to be obtained from another work center, or supervision would have to be split between this area and another area. If the number of personnel is increased to 7, the total system cost in present value terms rises to $2,410,875, still slightly ($199) less than the cost for Alternative I.

F. <u>CONCLUSION 6</u> - Any automated system would be preferred to the current method of operation, using any form of economic analysis as the criteria for comparison.

Both Alternatives I and II are highly preferred to the current method of operation either by NAVSUP PUB 529 analysis, or by the present value of savings method addressed in NAVSUPINST 7000.10A of 29 October 1974. If Alternative II, with 7 personnel, is compared to the current method of operation, a savings to investment ratio of 3.68 is computed, as well as a payback period of slightly more than 2-1/3 years. Alternative I, with 10 personnel, would fare almost as well.

The analysis of alternatives did not include variations of equipment such as manned stacker cranes and manned order-pickers with pallet shuttles. There has been no provision in the analysis

for the cost of fire protection for high-rise storage systems. This could average $5 - $6 per square foot of floor area covered,[1] not an insignificant cost, but certainly not large enough to affect the outcome of this analysis. There has been no provision for conveyors, transfer stations, sizing and weighing mechanisms or cutting apparatus for wire and cable. This would all be required to some extent to optimize the modernized facility. It would be required in basically the same quantity, at equal cost, in both Alternatives I and II and as such would not be a differential cost in the comparison of the two alternatives. It would have an effect on the comparison of alterantives I and II with the current method of operation, but the size of the differential in the total system costs in present value terms, 2.9 million, would be more than sufficient to cover the cost of this peripheral equipment.

There has been no sensitivity analysis conducted. Any variation in the rates for labor, utilities and fuel would favor Alternative II, as it is less dependent on these factors than either the current method or Alternative I. Both Alternatives I and II are sensitive to the cost of the equipment, both mobile and storage racks. Due to the small difference in costs between Alternatives I and II, it would be prudent to examine the results using different costs for turret trucks, stacker cranes and racks.

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[1] Material Handling Engineering, January 1977, pg. 62.

G. CONCLUSION 7 - From the comparison of alternatives, it should be obvious that a system with a large number of storage openings and a relatively low throughput cannot justify an automated facility with a surplus of capacity in retrieval equipment.

For example, the addition of one crane to Alternative II, changes its ranking from first to second in preference based on least total system costs. For this reason, any proposal for a stacker crane facility should seriously consider the use of transfer cars in multiple aisle installations.

G. RECOMMENDATION

Based on the research conducted in preparing this case, the recommended solution would be one that entails a 7 level, high-rise storage facility with approximately 7,500 openings, 2 unmanned storage/retrieval cranes with transfer cars capable of servicing approximately 700 transactions in an eight-hour shift located in the center of building 422. The area beneath the mezzanines could be used to accommodate those fast-moving items that were excluded from the high-rise system because of overhang, excess weight or excess number of pallets. Very large quantity bulk items such as rags, toilet paper, paper towels, sonobuoys and light bulbs should continue to be stored in the currently designated FAST complex utilizing conventional storage arrangements.

By concentrating as many of the fast-moving items in one area as possible, maximum savings would result. The FAST

program at NSC Oakland was attempting to do this, but conventional storage arrangements would preclude optimum savings because it would not be possible to locate enough fast-moving items in one facility with two and three high storage to realize the necessary savings in manpower and material handling equipment.

It was acknowledged that the inventory at any supply activity was dynamic and that there would be a constant migration between fast-moving and slow-moving categories. Therefore, it would be necessary to continually monitor the bulk storage inventory to ensure that only the fastest moving items were included in the modernized facility.

H. AREAS FOR FURTHER INVESTIGATION

It would be desirable if subsequent research could be conducted to survey the entire bulk storage population using the FC-10 demand frequency by location program. The research should extend to determining the actual transaction rate for fast-moving items, based on a sampling of transaction ledgers to identify the average number of pieces per issue and receipt, and the average availability for fast-moving items.

Additional research could be conducted to verify the height and weight requirements for a high-rise system to store bulk items.

It would be interesting to ascertain manufacturers' estimated or budgeted costs for a comparable sized system. Most manufacturers have computer simulation programs that can

prepare detailed cost estimates based on a few simple parameters such as the number of openings; size and weight of load; and throughput. A comparison of the various proposals, highlighting strengths and weaknesses would be of use in future planning evolutions.

Additional research could be conducted in determining the exact configuration of a high-rise system, including the interface with the inventory control, packing and shipping functions.

A major area of investigation could be the methodology utilized by the various services in obtaining warehouse modernization. The Air Force and Army spend considerably more on warehouse modernization than the Navy. A study could be conducted to ascertain how the other services are able to justify their major warehouse modernizations.

APPENDIX A

BACKGROUND OF THE SUPPLY SYSTEMS

An essential element of National Defense was the ability to apply military power where and when needed. Vital to this ability was the capability to sustain operations through a responsive logistic supply channel which guaranteed that the required goods would reach the combat area in a constant uninterrupted flow. This requirement had necessitated the development of integrated supply system to provide the Department of Defense with a method of handling its material in an efficient and businesslike manner, yet to give timely service to meet operational requirements.

Each individual service within DoD had its own peculiar operating characteristics and hence, its own supply system. The Navy supply system was designed and organized with the objective of insuring the maximum responsiveness of supply support to operations so that the Navy could accomplish its mission in the most effective manner possible. Consistent with this objective was the principle that economical use of funds, materials, and manpower was achieved in the operation of the system.

The Navy philosophy dictated that supply support would be integrated with operations programs emanating from the Office of the Chief of Naval Operations. Therefore, specific national programs developed by responsible Navy commands and offices, while interrelated and interdependent, had certain peculiarities

that required tailored supply support. This supply support, tailored to meet the peculiar demands of specific material programs required to support the operational programs, had created the necessity for a supply system composed of several material segments. Each segment of the Navy Supply System had its own material manager who was responsible for providing all elements of supply support required for the programs assigned to its segment. All segments of the supply system were under the coordination and direction of a single Navy agency to avoid duplication of authority, responsibility and functions. This agency was the Naval Supply Systems Command (NAVSUP) which exercised control over the operation of the Navy Supply System. NAVSUP was guided by inventory and material management control policy promulgated by the Chief of Naval Material.

Within NAVSUP, the basic elements of supply support (determination of requirements, procurement of requirements and distribution of requirements) were accomplished by Inventory Control Points, Stock Points and Distribution Points.

It was the responsibility of NAVSUP in conjunction with other hardware systems commands such as the Naval Air Systems Command to establish and administer levels of supply expressed in detailed terms for the material under their respective cognizance at all shore activities whether assigned to the operating forces or a part of the shore establishment. Levels of

supply guidelines were promulgated for determining requirements for material to be stocked. Each activity was assigned levels of supply for the general categories of material which the activity stocked. Both the cognizant technical command and NAVSUP jointly decided which segment would carry the items.

The responsibility for managing, cataloging, requirements determination, procurement, distribution, and scheduling for repair and disposal of equipment was vested with inventory managers which in the Navy included systems commands (Naval Electronics Systems Command), project managers (Strategic Systems Project Office), bureaus, offices, and inventory control points (Aviation Supply Office, Ships Parts Control Center and Fleet Material Support Office) under the command of NAVSUP. The inventory managers did not physically take possession of the material they managed, but rather directed it to be located at a particular storage activity (referred to as distribution or stock points), and provided guidance for local determination of items to be stocked in addition to the centrally managed items.

The distribution points carried stock for the supply support of designated primary stock points, and also were assigned supply support responsibility for secondary stock points in the immediate area, overseas secondary stock points, fleet units, and local support craft. The replenishment of distribution stock was directed by the inventory control points by procurement and direct delivery from government or commercial manufacturing

sources or from other government departments. The primary stock points carried stock for their own consumption, for designated secondary stock points and also for support of fleet units and attached support craft. The replenishment of primary stock points was accomplished in the same manner as with distribution points. Secondary stock points carried stock for their own consumption and for the support of assigned local craft. Secondary stock points were all those activities not designated as a distribution or primary stock point. They determined their own routine replenishment requirements and, as a result of this determination, submitted shipment requests, or requisitions to a designated source of supply. The designated source of supply normally would be a primary stock point or distribution point except that it could be replenished direct from commercial sources of supply for selected items of which it was a large consumer.

In an effort to effect economies by centralizing management of common supplies and services, the Defense Supply Agency was formed in 1962. It consisted of inventory managers and supply centers tasked with the responsibility of providing the most effective and economic support of common supplies and services to military services and other DoD components through a wholesale distribution system. In 1977, the name was changed to Defense Logistics Agency (DLA) to more accurately reflect its role in the National Supply System.

The DLA had been assigned integrated inventory management responsibility for items of subsistence, clothing and textiles, medical and dental supplies, packaged petroleum and certain construction, industrial, general supply, electrical and electronics supplies that the military services had determined need not be managed by each service. For those commodities and services for which management was assumed by the DLA, corresponding reductions in the resources allocated to the Navy were made. For this reason, it was determined that maintenance of satisfactory levels of support to the Naval establishment was dependent on integration of the Navy and Defense Supply Agency distribution systems. Thus, many Navy activities in the continental United States requisitioned material direct from DLA. DLA owned and managed selected stocks of material located at Naval supply centers, depots, shipyards and air stations.

A large Naval supply center such as NSC Oakland functioned as a specialized support depot in the DLA distribution system. It was a Navy-owned, operated and funded supply installation assigned a mission of stocking a selected range of DLA owned material for the support of local industrial and maintenance requirements, fleet units, and Navy shore activities as assigned by NAVSUP. Replensihment of specialized support depots was centrally controlled by the cognizant defense supply center. Issue of material, however, was a local responsibility, with requisitions being locally received and processed by the Naval supply

activity. In addition, issue of material could be directed by defense supply centers to satisfy requisitions processed centrally.

The General Services Administration (GSA) was assigned the responsibility for management of those commodities commonly used by Federal agencies which were commercially available on the civilian economy and not predominantly of a military nature. By agreement with DLA, GSA exercised item management over such commodities as hand tools and paint, notwithstanding the military nature of some of the items and their use in military operations or weapons system support. GSA prepositioned wholesale stocks of these items at large Naval supply centers for eventual drawdown as Navy retail stocks.

In a Naval supply center such as NSC Oakland, material could arrive as a result of Navy Inventory Control Point, Defense Supply Center, General Services Administration, or NSC Oakland requirements determination. Material could be issued as a result of a customer demand direct on NSC Oakland, or as a result of redirection from one of the other inventory control points. Very seldom did the man who physically had to receive, store, and issue the material know how much was arriving, how long it would have to be stored, or how often it would be demanded. The physical management of material in the Navy supply system was very much a case of management by reaction.

APPENDIX B

MODELS FOR FAST PROGRAM

Department of the Navy
MEMORANDUM

50D/WTL:le
Date: 19 February 1975

FROM: 50D

TO: 00
VIA: 50/0

SUBJECT: FAST Program; models for

Enclosed:
(1) Assumptions of the Models
(2) Definitions and calculations of standards for the models
(3) Qualification as a FAST item model
(4) Qualification as SLOW-moving model
(5) Appendix A - Bulk issue standards for FAST and other than FAST

1. The FAST Program is a program that identifies all items by demand frequency so that it is possible to centralize the storage of fast-moving bulk items to speed the issue of these items. Unfortunately, no decision rule existed that enabled one to determine what was a bona-fide fast-moving bulk item. Conversely, no decision rule existed that allowed the determination of the qualifications of a slow-moving bulk item. Experience of personnel at NSCO suggested that possibly 25 demands a year or more qualified an item as fast-moving and less than 5 demands a year qualified an item to be classed as a slow-mover.

2. In an effort to define the decision rules to be used to determine fast and slow-moving bulk items, two models have been developed. Enclosures (1) and (2) list all the assumptions of the models and the definitions and calculations of the standards used in the models. Enclosure (3) is the model to be used as a decision rule for qualification of an item as a fast-moving bulk item and enclosure (4) is the model to be used as a decision rule for qualification of an item as a slow-moving bulk item. Enclosure (5) contains the calculations of the bulk issue standards for both FAST and for other than FAST warehouses.

3. The models are intended as rule-of-thumb models and are not insurors of guaranteed answers. Many factors affect the models, many factors are not included in the models, and the models are sensitive to changes in the standards used. The model formulas can, however, be used with changed standards wages, etc., to obtain decision rules. The decision rules will replace the "hunch" or guessed-at figures now in use.

4. The general results of each model were calculated using the best standards and best estimates of those factors for which no standard exists. The general results obtained were:

a. The demand frequency a bulk item must experience in order to qualify as a fast-moving item and be moved to a FAST warehouse is 18.5 or more demands per year.

b. The demand frequency a bulk item must experience in order to qualify as a slow-moving item and be moved from a FAST warehouse is 6.3 or less demands per year.

c. Demand frequencies between these two figures - or frequencies between 6.3 and 18.5 demands per year - are in the gray area of being neither fast nor slow-moving items. Items experiencing these demand frequencies should remain in their present locations whether the location be in a FAST warehouse or not.

5. Under the assumptions of these models, and using the general results as calculated, if an item qualifies as a FAST item, is moved to a FAST warehouse and is issued from that warehouse, a savings to NSCO of $3.07 per line item issue from a FAST warehouse should occur.

6. Therefore, based on these results, it is recommended that:

a. The FAST program concept at NSCO be expanded to include all possible bulk items and that the models be used for decision rules in the program.

b. The questions that arose during the model creation be further investigated by the Material Department for possible implementations. These include:

(1) Should there be a dedicated transportation run from the FAST warehouses to the packing/shipping functions every hour or so?

(2) If FAST warehouses are used, should all bulk issues and receipts be coordinated from the FAST warehouses?

(3) Should there be FAST warehouse crews and a mobile crew to receipt and issue from the other bulk warehouses?

Very respectfully,

W. T. LEE

Copy to:

51	301
100	301.2
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ASSUMPTIONS OF THE MODELS

1. The following assumptions were made in creating the models:

a. It is desired to obtain 95-100% on time issues from FAST warehouses.

b. Special types of material are not eligible for FAST and must stay in separate warehouses, including:

(1) Radioactive - Building 214
(2) Security of Pilferable Items - Building 412
(3) Classified - Building 310-2
(4) Clothing - Building 734
(5) Hazardous Flammable - Building 431
(6) Repairables - Building 543/544
(7) Large bulk steel - Lot 613
(8) Large bulk - all lots in 600 block
(9) Provisions - ALAFAC

c. All items under study could, if qualified, move into FAST warehouses. This may not be true for certain items - cable, wire, steel, etc., that require access to cutting machines, etc., located in the current warehouses. Individual decisions must be made on each item whether to move to FAST or not.

d. FAST warehouses should be as close as possible to packing/shipping functions. It is assumed that buildings 342/343/443 will be FAST warehouses.

e. FAST-moving bulk items can be issued faster from a centralized FAST warehouse than from scattered warehouses. If this were not true, there would be no reason for FAST warehouses to exist.

f. It was assumed that no FAST building now exists so that if an item qualified for FAST it would have to be moved to a FAST warehouse. Conversely, if an item did not qualify for FAST, it was assumed to be located in a warehouse that was not opened daily.

g. No attempt was made to quantify the transportation cost to shipping/packing for FAST or other warehouses; although, it was assumed that the transportation cost for FAST items to packing/shipping was no more (and should be less) than for other warehouses.

h. It was assumed that the average rewarehousal transportation time between warehouses was 10 minutes regardless of the warehouse location.

i. It was assumed (based on experienced estimates) that the average rewarehousal involved one pallet load or one Measurement Ton (M.T.) of material.

2. Certain questions arose during the model creation that were not explored. These questions included:

a. Should there be FAST warehouse crews <u>and</u> another crew to handle other bulk? Should the same crew or another crew be used to rewarehouse to FAST?

b. Should a mobile crew, if established to handle slow-moving bulk issues, have receiving warehousemen and pickers and packers (if desired)? Is it feasible/possible to train a mobile crew to do all three operations?

c. If FAST warehouses are used, should all bulk issues and receipts be coordinated from the FAST warehouses?

d. Should there be a dedicated transportation run from the FAST warehouses to the packing/shipping functions every hour or so?

DEFINITIONS AND CALCULATIONS OF STANDARDS FOR THE MODELS

1. Based on input from NSCO codes, the following standards and/or estimates are used to calculate the quantities of the models:

a. The average grade and salary of warehouseman assigned to the Storage Division is Warehouseman WG-05, step 4 at $7.95 per manhour accelerated straight time. Accelerated straight time will be used in the models since that is the cost rate to NSCO for a manhour of work.

b. The composite standard for Outgoing Rewarehousing is 0.2795 hours/Measurement Ton (M.T.) and the composite standard for Incoming Rewarehousing is 0.1162 hours/M.T. These standards include all paperwork required, etc.

c. The current standard to keypunch and/or verify is 8000 strokes per hour. Key strokes required for a location change (ZEL) varies with the number of locations added/deleted. It is estimated that an "average" ZEL would require approximately 45 strokes. In addition, there is usually a related ZQL inquiry input requiring a basic 12 strokes. Therefore, the average key strokes for a location change is assumed to be 60 strokes for the entire process.

d. The average grade and salary of a keypuncher is GS-4, step 5 at $5.58 per hour accelerated straight time.

e. The composite standard for bulk issues from other than FAST warehouses is 3.91 line items per hour. The composite standard for issues from FAST warehouses is 4.19 line items per hour. These figures are computed in Appendix A.

f. There is no standard of the time required to open a closed warehouse. The estimated times ranged from 10 minutes to 25 minutes. For this reason, the results of the models are shown for several assumed times in Charts #1 and #2. In general, however, the average time required was approximately 15 minutes and the general result of the models were computed using that time.

2. Using the above input, the following figures were calculated for use in the models:

a. Rewarehouse Cost (RC) = average cost to rewarehouse to another location = Salary x (Outgoing rewarehousing + Incoming Rewarehousing + Transportation time) = $7.95/ hour x (.2795 + .1162 + 10 minutes) = $4.47.

Enclosure (2)

b. Location Change Cost (LC) = average cost to make a warehouse location change to MSIR = Salary x (standard rate x strokes) = $\$5.58/\text{hour} \times \left(\frac{1 \text{ hour}}{8000 \text{ strokes}} \times 60 \text{ strokes}\right) = \$0.04$.

c. Warehouse Fixed Cost (WFC) = average fixed cost of opening a closed warehouse = salary x time = \$7.95/hour x 15 minutes = \$1.99.

d. Bulk Issue Cost (BI) = average (standard) cost to make an issue from other than a FAST warehouse = Salary x rate = $\$7.95/\text{hour} \times \frac{1 \text{ hour}}{3.91 \text{ line items}} = \$2.033$.

e. FAST Issue Cost (FI) = average (standard) cost to make an issue from the FAST warehouses - salary x rate = $\$7.95/\text{hour} \times \frac{1 \text{ hour}}{4.19 \text{ line items}} = \$1.897$.

f. Therefore, BI-FI = \$2.033 - \$1.897 = \$0.136.

Enclosure (2)

QUALIFICATION AS A FAST ITEM

MODEL

1. Define the following terms, as shown in the definitions and calculations:

RC = the average cost to rewarehouse to another location
LC = the average cost to make a warehouse location change to the MSIR
WFC = the average fixed cost of opening a closed warehouse
FI = the average (standard) cost to make an issue from a FAST location
BI = the average (standard) cost to make an issue from a bulk location other than FAST

2. In order to qualify as a FAST item, the reasoning is as follows:

a. To make an issue from a FAST warehouse, the item must have been moved to the FAST building, a warehouse location change made to the MSIR, and the item must be picked for issue from the FAST location. The formula for this action is

RC + LC + FI (#demands)

b. Opposed to this action, if the item is not in a FAST warehouse, the assumption was made that the warehouse was not opened daily. Then, to make an issue from these warehouses, the warehouse must be opened and the item issued at the slower rate; that is:

WFC + BI (#demands)

c. In order to qualify as a FAST item, the cost of issuing from a FAST warehouse must be equal or less than the cost of issuing from a different warehouse. So:

RC + LC + FI (#demands) = WFC + BI (#demands)

Solving this equation gives:

$$\#\text{demands} = \frac{RD + LC - WFC}{BI - FI}$$

d. #demands as used here denotes the frequency of demands, not the quantity issued. Solving this equation will give the economic breakeven point that will qualify an item to become a FAST item. The equation contains hidden qualities that affect the decision; as an example - if the item is quite bulky or if

a large quantity is carried at NSCO the cost to rewarehouse will be larger and therefore the demand must be higher to qualify it for FAST. Chart #1 contains the results for qualification as a FAST item depending on the time required to open a closed warehouse. The general result shows a demand frequency required of more than 18.5 demands per year.

CHART #1

QUALIFICATION AS A FAST ITEM DEPENDENT ON TIME ESTIMATE TO OPEN A CLOSED WAREHOUSE

GIVEN, AS STANDARD COMPUTED:

REWAREHOUSE COST (RC)	= $4.47
LOCATION CHANGE COST (LC)	= $0.04
DIFFERENCE IN COST OF TYPES OF ISSUES (BI-FI)	= $0.136

Time estimate to open a closed warehouse	WFC	Number of yearly demands to qualify as a FAST item
10 minutes	$1.33	23.4
12 minutes	$1.49	22.2
15 minutes (general result)	$1.99	18.5
20 minutes	$2.65	13.7
25 minutes	$3.31	8.8

NOTE: If the time required to open a closed warehouse to make an issue falls below seven (7) minutes, then the FAST program, as computed, should be discontinued and items issued from where ever the location may be.

QUALIFICATION AS SLOW-MOVING

MODEL

1. For bulk items to be classed as slow-moving:

a. Using the same definitions as before, then, for an item to be classed as slow-moving, the demand frequency must be small enough to justify moving it from a FAST building to another warehouse (or to leave it in a warehouse other than the FAST warehouses). Assuming the item is located in a warehouse other than the FAST warehouses - if the item does not qualify as a FAST item using the model developed, then it is a slow-mover and remains where it is. Assuming, on the other hand, that the item is located in a FAST warehouse, the reasoning is as follows:

(1) The item is stored in a location that can be used for a FAST item, but a FAST item cannot be moved into that location until the slow-mover is gone. Therefore, the slow-mover is costing NSCO a penalty cost equal to what could be saved if a FAST item were in that location. The penalty cost, equal to the FAST savings, is: the difference in costs to issue from a FAST building vice a different bulk building <u>plus</u> the cost savings of not opening a closed warehouse multiplied by the demand frequency. That is:

((BI-FI)(Average Salary) + WFC) (#demands)

(2) The cost of moving the item from the FAST building and then later having to issue from a closed warehouse is:

RC + LC + WFC + BI(#demands).

Therefore, since this cost must be equal or less than the penalty cost to justify moving an item from FAST warehouses:

RC + LC + WFC + BI(#demands) = ((BI-FI)(Aver.Salary) +

WFC (#demands).

Solving - $\#\text{demands} = \dfrac{RC + LC + WFC}{(BI-FI)(Avg.Salary) + WFC - BI}$

Using the figures calculated for the general result in the FAST qualification on case model, the general result for moving slow-moving items from FAST warehouses is a yearly demand frequency of <u>6.3 demands or less</u>.

(3) Chart #2 contains the results for qualification as slow-moving items depending on the time to open a closed warehouse.

CHART #2

QUALIFICATION AS SLOW-MOVING DEPENDENT ON TIME ESTIMATE TO OPEN A CLOSED WAREHOUSE

GIVEN, AS STANDARDS COMPUTED:

REWAREHOUSE COST (RC)	= $4.47
LOCATION CHANGE COST (LC)	= 0.04
DIFFERENCE IN COST OF TYPES OF ISSUES (BI-FI)	= 0.136
AVERAGE SALARY	= 7.95/hour
COST OF BULK ISSUE (BI)	= 2.033

Time estimate to open a closed warehouse	WFC	PENALTY COST	Number of demands (or less) to qualify as slow-mover
10 minutes	$1.33	$2.41(demands)	15.5
12 minutes	1.49	2.57(demands)	11.2
15 minutes (general result)	1.99	3.07(demands	6.3
20 minutes	2.65	3.73(demands)	4.2
25 minutes	3.31	4.39(demands)	3.3

ANNEX A

BULK ISSUE STANDARDS FOR FAST
AND
OTHER THAN FAST

OTHER THAN FAST:

Work Center[1]	Standard Time	Daily Average Work Unit	Weight	Composite Contribution
Section I,				
Unit A	.2518	100.5	.1313	.0331
B	.2691	73.9	.0966	.0256
C	.2765	18.1	.0236	.0065
Section II,				
Unit A	.2915	168.0	.2195	.0634
C	.2357	36.3	.0474	.0112
D	.2207	188.2	.2459	.0543
Section III,				
Unit A	.2533	37.7	.0493	.0125
B	.3488	29.8	.0389	.0136
C	.2415	112.8	.1474	.0356
				.2558 or 3.909 line items/hour

FAST:

Work Center	Standard Time	Daily Average Work Unit	Weight	Composite Contribution
Section III,				
Unit C	.2415	112.8	.346	.0836
D	.2374	213.0	.654	.1553
				.2389 or 4.186 line items/hour

1. Reorganization has changed the arrangement of work centers, but not the basic concepts or statistics. Certain units have been excluded due to the restricted nature of the material.

APPENDIX C

NSC Oakland Storage Division Rewarehousing Project

301.21:AW:rbw
21 April 1977

MEMORANDUM

From: 301.21
To: 301
Via: 301A

Subj: Storage Division Rewarehousing Project

Ref: (a) 301:WMH:rbw of 18 March 1977

Encl: (1) Rewarehousing Plan and Procedure

1. Enclosure (1) is submitted as the proposed plan to accomplish Directives outlined in reference (a).

2. Recommendations for monitoring fast, clerical effort, and remote terminal needs are still being developed and will be submitted at a later date.

A. WEBSTER

PHYSICAL REWAREHOUSING PLAN AND PROCEDURE

1. The basic objective of the rewarehousing project is to accomplish a more efficient material handling and productivity operation. In order to achieve that goal, many buildings will have to be closed. Buildings 722, 724, 731, 732, and 741 will be closed once all "fast" items have been removed. The remaining buildings in the seven and eight hundred blocks will be managed from Building 734, which is the major work center. Buildings 310, 221, 531, 541, 542, 131, and 141 will also be closed and managed from their respective work centers, according to the established open-close work scheduled.

2. It is further determined that if any economies are to be achieved, every item that has a one-hit possibility (per week) must be moved out of the buildings that are proposed to be closed. Accordingly, the following are proposed:

a. That all items located in Buildings 722, 724, 731, 732, and 741 having a frequency of 26 or more hits be moved into fast.

b. That all items located in Buildings 422 and 522 having a frequency of 52 or more hits be moved into fast (after careful review).

c. That all items located in Buildings 541 and 542 having a frequency of 26 or more hits be moved into fast.

d. That all items located in Building 310 having a frequency of 51 or more hits be moved into fast.

e. That all items located in Building 221 with a frequency of 26 or more hits be moved into fast.

f. That all items located in Building 222 with a frequency of 51 hits or more be moved into fast (except I cog).

g. That since Building 732 shows the highest number of high frequency items and Building 342 shows the highest number of zero-hit items, these two buildings be the first warehoused.

NOTE: It is anticipated that any problems to be encountered during the program should surface in these high-count warehouses.

Rewarehousing teams will be assigned to the warehouse supervisor of the building in which they are working. Each team will have a leader who will work with the supervisor of the building to coordinate all effort taking place on the project.

The team leader will be responsible for distribution of all cards to work crews, collecting and delivery of all work cards for processing to Storage Control Section.

h. All stock determined to be zero (0) or low-frequency items will be moved out of Buildings 342, 343, 344, and 443.

i. All stock moving out of the four buildings listed above will be located in various buildings that now have sufficient space to accept more stock.

j. Every item that is identified as high frequency (fast) will be moved into Buildings 342, 343, 344, and 443.

k. Exception: There are a number of items that, although identified as fast, are not practical to move - such as: lifeboats; life rafts; sonobuoys; major equipment; items that require cutting; all firm and repairable; auto tires; F, S, Z cog; etc.

l. Three decks of colored cards (printed on blankside) will be provided for the rewarehousing teams to process material movement (buff, yellow, pink). Primary sort: Group 1 - all cards with definitive locations, significant digits CC 3-11; Group 2 - all cards with symbolic locations, significant digits CC 3-5; zeros CC 6-10, significant digit CC 11; Group 3 - all others.

m. Group 1 cards will be broken up into small workable packets (25) banded and made ready for the warehouse crew to pull material for movement.

n. Group 2 cards will be passed across the manual locator of each building to obtain the definitive location. All cards will then be broken up into small workable packets (25) banded and made ready for the warehouse crew to pull material for movement.

o. It is anticipated that the physical movement of material from one warehouse into another warehouse will include both fast-in and slow-out, thereby using the same warehouse crews in both warehouses and the same transportation manpower and equipment.

APPENDIX D

Memorandum - Closing of Bulk Storage Buildings

Department of the Navy
MEMORANDUM

301.2:TNT:vlc
Date: 18 April 1977

From: 301.2

To: Distribution List

Subj: Closing of Bulk Storage Buildings

1. Some Bulk Storage buildings will only be opened on Tuesday and Friday, and then only if there are priority issues to be made or direct truck deliveries. The following are the buildings to be closed and the contact points for: (a) Group I Issues; (b) bearer pick-ups; (c) direct truck deliveries:

131/141	L. Reed G. Givens	X5003
221/222	F. Martin J. St. John	X5837
531	G. Elliott R. Perry	X6376
541	L. Reed G. Givens	X5003
542	R. Miller J. Hale	X5982
731/741	R. Anderson J. Byron	X6340
831/832	C. Wafer K. Turnage	X5284

T. N. TOKLAS

Distribution List:

101	105	304
101.1	105.1	304.1
101.4	105.11	304.2
101.5	105.12	304.3
101.6	105.2	

OPNAV 5216/144 (REV 6 70)

APPENDIX E.

DEPARTMENT OF THE NAVY

Memorandum

301.2:TNT:vm
DATE: 6 Sept. 1972

FROM: 301.2
Via: 301

TO: 300A

SUBJ: Automatic Storage System (TRIAX RETRIEVER)

Encl: (1) TRIAX Brochure

1. Enclosure (1) describes a system that had possibilities for use in storing and retrieving (issuing) in Bulk Storage that did not lend themselves to pallet tiering. Inquiry developed that American Cyanimide Corp. had such equipment in their plant at Rocklin (near Sacramento). I made arrangements to see this operation and did so on 25 August. The plant manager assigned an engineer to show me around and answer questions. In addition the Triax Retriever operator freely volunteered information.

2. This particular system has three retrievers each operating in an aisle that had 5 openings high and 34 tiers deep or 340 locations for a total of 1,020. The openings were 5' deep because this company stores fairly large rolls of paper, weighing up to 1,800 pounds, used in making Formica board. Normally 2 men operate the three retrievers plus cutting and stripping machines. Due to illness one man had been doing all the operations for over three weeks. There were a lot of bugs in the system when first installed six years ago but apparently was working well with very little down time.

3. The company has ordered another TRIAX RETRIEVER bank, which certainly demonstrates satisfaction. This system feeds material to highly complex production machinery; break-downs could be very costly.

4. The following statistics on the new retriever were offered:

a. COST:

	\$75,000	Machine
	5,000	Freight
	\$80,000	Total Installed

(The pallets used could be an additional cost. Formica has a special $1\frac{1}{4}$" plywood board that costs them \$5,000 per aisle).

b. CYCLE TIME: 4.6 minutes total for two commands
14.1 in
14.1 out
Hourly rate

(This is about 7 times faster than what we do today).

301.2:TNT:vm
6 Sept. 1972

Subj: Automatic Storage System (TRIAX RETRIEVER)

5. Conceivably a six or seven aisle system could be installed in Bldg. 422 that would not interfere with the overhead crane for about $5-600,000 that would do about half of all the bulk stows/issues that were not special (such as steel, hazardous, clothing, etc.) with about 8 people, eliminating at least 30 warehouse types and amortizing in 2 years.

6. Please return brochure to the undersigned when finished.

Very respectfully,

T. N. TOKLAS

MEMO ROUTING SLIP

NEVER USE FOR APPROVALS, DISAPPROVALS, CONCURRENCES, OR SIMILAR ACTIONS

	TO	INITIALS	CIRCULATE
1	300A Tin	DATE	COORDINATION
2	~~300~~ ~~IDP~~		FILE
3	BOM - Retain For		INFORMATION
4	Future Possible Use		NOTE AND RETURN
			PER CONVERSATION
			SEE ME
			SIGNATURE

REMARKS

Enclosed is Tido's report on TRIAX. He speaks only to Bldg 422 however I feel we should be looking a versus area - this system could also work in bulk storage Alameda. Any ideas?

This is one of the items [illegible] the stowing [illegible] Stocking

VK!

FROM: 301

DATE

PHONE

DD FORM 1 OCT 60 95 REPLACES DD FORM 94, 1 FEB 50 AND DD FORM 95, 1 FEB 50 WHICH WILL BE USED UNTIL EXHAUSTED. [illegible] PRINTING OFFICE: 1971—483-984/14

APPENDIX F.

NSC OAKLAND ECONOMIC JUSTIFICATION FOR HIGH-RISE AUTOMATED STORAGE/RETRIEVAL SYSTEM

1. DESCRIPTION OF PROJECT:

Proposal is an Automated Storage and Retrieval System (AS/RS) that will substantially replace warehousemen and fork lifts in a high-rise (46 feet) large capacity (10,000 pallets) high volume (1,200 - 1,600 receipts and issues per shift) at estimated cost of $2 million to $3 million.

2. PROJECT BENEFITS ABSTRACT:

AS/RS will reduce labor and equipment replacement costs; reduce error rate; reduce damages; reduce paper work; reduce pilferage; reduce fuel, electricity usage; increase productivity per man hour; increase space utilization; increase safety performance.

Reduce supervision, reduce housekeeping, reduce maintenance costs.

Improve customer service through:

More efficient scheduling.

Consolidated shipments.

Faster service.

AS/RS would dramatically improve NSCO ability to respond to DSA managed item MRO's.

3. SYSTEM PARAMETERS:

a. Use existing space in center of Building 422. Approximate space available: length: 590 feet

width: 98 feet

height: 46 "

(Above area is free of columns.)

b. Use standard Navy pallets measuring 40" x 48" wing tip as specified in NAVSUP INST 4460.3A dtd 12 DEC 1974, Chap. II.

c. Height of material and pallet:

48 inches	72%
66 "	28%

d. 10,000+ pallet openings in two banks of 5,000+ facing each other and separated by a 30 foot interchange working area.

e. Capacity:

1600 issues/stows per 8 hours in a 3:1 ratio.

f. Rider-less stacker cranes to be controlled by a process controller having ability to direct stacker by minimal distance; by customer; by interrupt (Hi-Pri); retrieve on call for add-on small lot receipts.

g. Process controller must be able to locate any of 5,000 different line items (in 10,000 openings) by National Stock Number, including Cog condition codes; (a total of 15 characters) FIFO. Pallets per stock number will range from 1 to 5 with a mode of 2. No NSN inventory function is required of process controller.

h. Stacker crane to deliver pallets to one of several sort platforms for skimming of issues. Transfer cart may be employed to accomplish above. Crane to respond to impulse controlled by warehouse picker, when he is through with a pallet, directing

restow of balance of pallet and location update, if needed.

i. Average issue involves picking 7 packages from pallet.

j. Average package weights:

50# or less:	50%
51-100#:	28%
101+#:	22%

From above, it is apparent that fork lift or similar assistance will be necessary about 20% of the time.

k. Completed system design to include ability to transfer issues from work platforms (above) to packing stations in south wing, using power and free or similar conveyor that will not block nor interfere with traffic aisle adjacent to south side of AS/RS. (Height underneath wing 17' 10".)

l. Present electric current in Building 422 is: AC

208 Volt

3 Phase

60 Cycle

m. Although system will normally be used one shift, design must contemplate three shift usage.

n. System must include possible alternates when down time (unplanned) occurs to stacker crane or process controller.

o. Safety requirements must meet requirements of OSHA, NEMA, ANSI, etc. in regards to:

(1) Decibel level

(2) Fire Control

(3) Zone 3 earthquakes

(4) Rack strength

(5) Other known safety criteria.

p. Expected maintenance down time should be stated:

(1) If a maintenance contract is available it should be offered as a separate detail for consideration.

(2) A spare parts list need not be included, but a dollar figure should be stated.

q. Training (learning time) shall be included as a separate identifiable cost item.

(1) Include cost of 15(?) instruction manuals.

r. Soil, piling load bearing constraints are available from NSC Oakland, Code 43.

s. Acceptance will be after satisfactory performance tests with actual storage items on hand, including line issues/receipt.

t. Necessary environmental control statements should be included.

u. State warranty period and general conditions.

4. OPTIONS

1. Sling Pallet (identify cost)

2. Direct line and/or compatibility with Burroughs 3700.

3. 3,000# (107. of capacity)

4. Two pallet rack openings

sizes:	48" including pallet	72%
	66" " "	28%

5. Issue by customer.

6. Process controller to print out production statistics; number of vacant spaces by aisle daily; complete listing by NSN and location monthly.

7. Clearance underneath mezzanine is 17' 11". If feasible, add sortation system that would accumulate by customer for consolidated packing.

8. Feed pallet loads to north mezzanine (approximately 21' high - 250 psf limit).

9. Ability of process controller to accumulate given NSN's for up to 7 calendar days on Issue Group III's.

5a. SAVINGS	Present Costs	Present Value
1. a. Personnel		
30 WG-5 Warehousemen	$ 583,440	$3,761,438
7 WG-6 Warehousemen	142,834	920,851
2 WS-6 Warehousemen	55,286	356,429
	$ 781,560	$5,038,718
b. Fork Lifts		
Maintenance $335.60		
Operations 167.72		
20(daily use) X 503.32 =	$ 10,066	$ 64,896
Replacement:		
25 in 10 years @ $8,125= (8 year average life)	$ 203,125	$1,309,547
c. Floor Spaces		
2 Warehouses @ 120 sq. ft. ÷ 250,000 sq. ft. x 50¢ =	$ 125,000	$ 805,875
d. Electricity 2 Warehouses @ $72 =	144	928
e. Supplies (est.)	500	3,224
f. Pilferage	10,000	64,470
	$1,130,395	$7,287,658

5b. PROPOSED

	Costs	Present Value
1. One-Time Costs		
a. AS/RS	$2,000,000	$16,117,500
b. 2 Fork Lifts	16,250	104,764
c. One-Time Costs (moving/trn'g)	70,569	454,958
d. Space (96,000 sq.ft. @ 50¢)	48,000	309,567
Total One-Time Costs	$2,134,819	$16,986,678
2. Recurring Costs		
a. Personnel (9)		
6 WG-6 Warehousemen	$ 122,429	$ 789,300
1 WS-5 Foreman	26,666	171,916
1 GS-7 Console Opr	21,154	136,380
1 GS-9 Console Opr	17,326	111,701
9 Totals	$ 187,575	$ 1,209,297
b. Fork List (2 each)		
Maintenance $335.64		
Operations 167.72		
$503.32	503	3,243
c. Electric Power		
AR/RS (62MKWH per yr)	1,916	
Lights at Working Area	216	
	$ 2,132	$ 13,745
d. Maintenance	$ 25,000	$ 161,175
e. Supplies (est.)	600	3,868
	$ 215,810	$ 1,391,328
Item 1 + Item 2	$2,376,954	$18,378,006

Ratio of Costs to Savings: 2.5.

6. STAFFING

Now: 1,000* L/I Issues/Receipts @ 4 per hr

250 M/H ÷ 8 = 31+ man days

Loc. Audit	1	
	32	
Leave & Tng	5	(16%)
	37	

Under AS/RS:

1,000	L/I
x 7	Average number loose pieces per L/I
7,000	
÷ 3	Hours
875	Pieces per hour
÷60	Minutes
14.6	per minute
3	per minute per man
5	Warehousemen required
1	Leave/Training
6	
2	Console Operators
1	Supervisor
9	TOTAL

RECAP: Now:	37	ceiling	points
Then:	-9	"	"
Savings:	28	"	"

*NOTE: Daily average capacity of 1,200 L/I includes inventory counts; repairable inductions; full pallet loads; heavy lifts.

7. NOTES

1. Based on 10 year project @ 6.447 (Table B of NAVSUPINST 7000.10A.

2. Wage rates include 38.31% for overhead (leave, insurance, etc. as required.) Rates supplied by Code 52.1.

3. Source: Code 303.

4. Lights needed in working area and by console and supervisor's office:

3,000 Watts x 9 hours = 27,000 per day

27 X 260 = 7,020 KWH per year

7.02 MKWH X 30.806* = $216.

AS/RS power usage based 50 HP 460 volt 65 AMP motors in the retrievers, or: 29,000 Watts per day x 8 retrievers.

*PWCSFRANINST 7030.1A.

5. Several industry representatives suggested 1% for maintenance (including parts.)

6. Pilferage based on Memo RSW:rbw dtd 29 July 1976 to Code 301.2 which indicated a loss of $8,234 in footwear alone during a 5-month period.

7. a. Moving Costs: 10,000 Plts ÷ 4 man hours = 2,500 man hours X $9.47 (composite rate of 3 - WG-5 to 1 WG-6) = $23,675.

b. Training = 25% of personnel (for 1 year). Total (item 2a) or $187,575 ÷ 4 = $46,894.

APPENDIX G.

NAVAL SUPPLY CENTER

OAKLAND, CALIFORNIA 94625

6551

IN REPLY REFER TO:
43.1:VWG:es
01 NOV 1976

From: Commanding Officer, Naval Supply Center, Oakland, California
To: Commander, Naval Supply Systems Command, Code 0322A, Washington, D. C.

Subj: Floor Loading Investigation of Bldg. 422 Report; forwarding of

Encl: (1) Subject Report
(2) Structural Dwgs of Bldg. 422 (8 copies)

1. Enclosures (1) and (2) are forwarded for your information in preparation of project for new automated storage and retrieval system in Building 422, Naval Supply Center, Oakland.

ENGINEERING SERVICE REQUEST
NS 2038 (Rev. 2-61)

Submit in Quadruplicate

1. Copy No. 2

2. FROM COMMANDING OFFICER, NAVAL SUPPLY CENTER, OAKLAND, CALIFORNIA 94625

TO ~~COMMANDING OFFICER, WESTERN DIVISION, NAVAL FACILITIES ENGINEERING COMMAND~~
SAN BRUNO, CALIFORNIA 94066

4. REFERENCES

5. SSOB OR SPECIAL PROJECT NO.

6. ENCLOSURES (Check)

☐ NAVCOMPT 140 ☐ NAVCOMPT 2038 ☐ NAVCOMPT 372 ☐ OTHER (Explain)

7. TYPE OF SERVICES REQUESTED
ENGINEERING STUDY, FLOOR LOADING, BUILDING 422

8. DETAIL OF WORK

REQUEST ENGINEERING STUDY FOR INCREASING THE LIVE FLOOR LOADING IN BLDG. 422 FROM 500#/SQ. FT. TO 1800#/SQ. FT. PROVIDE METHOD AND COST ESTIMATE. SERVICE REQUIRED FOR PREPARATION OF BUILDING TO RECEIVE NEW AUTOMATED STORAGE AND RETRIEVAL SYSTEM.

9. FOR INFORMATION CONSULT (Name, title and phone)	10. OFFICIAL REPRESENTATIVE (Signature and date)
V. GIBSON, GEN. ENGINEER - 466-6491	S. R. BEATTIE 11 MAY 1976

RESERVED DPWO ENTRIES ONLY

11. DATE RECEIVED IN DPWO	12. SERVICES TO BE PERFORMED BY DPWO (Check)	13. DPWO PROJECT NO.
	☒ DESIGN ☐ OTHER (Explain)	7157011

14a. SCOPE OF CONTRACTS	14b. NO. OR OTHER NO.
INTERIM ENDORSEMENT: Engineering study to be in-house.	Pm 13
Projected milestones follow:	
Study Complete: 31 Aug 1976	
Close Out ESR: 30 Sep 1976	

15. OTHER
For further information, contact D. L. Illian, EIC, Autovon: 859-2440

Copy to: Station, 04A1, 09A2.57, DPWO INTERIM ENDORSEMENT DLI(EIC) 402:DLI:ls

16a. ESTIMATED COMP. DATE

16b. AUTHORIZED REPRESENTATIVE (Signature and date)

R. S. BATHA, Head, Structural Br.

Ser:402/286
23 Jun 1976

Copy to: Station, 04A1, 09A2.57, DPWO FINAL ENDORSEMENT TO ORIGINATOR DLI(EIC) 402:DLI:ls

ENCLOSURES FOR FINAL ENDORSEMENT:

☐ DWGS. & MAPS ☐ SPECS. ☒ REPORT ☐ OTHER:

The enclosed report completes action on this ESR.

Ser:402/531
20 Oct 1976

EST. COST (If applicable)

AUTHORIZED REPRESENTATIVE (Signature and date)

R. S. BATHA, Head, Structural Br.
Code 402

REPORT

ON

FLOOR LOAD INVESITIGATION

OF

WAREHOUSE BUILDING 422

at the

U.S. NAVAL SUPPLY CENTER

OAKLAND, CALIFORNIA

SEPTEMBER 1976

DEPARTMENT OF THE NAVY
WESTERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
SAN BRUNO. CALIFORNIA 94066

12ND WESTDIV 5000/1 (7-72)

TABLE OF CONTENTS

I. Summary

This report presents the results of an investigation into the engineering feasibility and preliminary cost for the foundation of a new storage system to be installed in the existing building No. 422 at the Naval Supply Center, Oakland, California.

The recommended scheme for the new foundation is shown on the sketches accompanying this report. The proposed foundation can be modified to suit existing construction and take advantage of existing piling.

A detailed engineering cost estimate for the proposed work is given in Section VII of this report. The estimated construction cost for a new floor in the high bay area of building 422 is approximately $1,200,000.

II. Purpose of Study

The purpose of this study is to determine the feasibility of increasing the live floor loading in Bldg. 422 from 500 psf to 1800 psf. The study included an investigation of the physical requirements for the new storage system, modifications necessary to the existing concrete floor, and consideration of subsurface pile construction.

III. Description of Building

The building, constructed in 1941, is a steel frame warehouse consisting of a high center bay flanked by a lean-to bay on each side with reduced ceiling height. The structural floor is 600 ft. long, 200 ft. wide and supported by 40 foot long piles. The piles are reinforced precast concrete type, spaced 10 ft. on center and are assumed to be 12 inches square. The pile caps are 13" deep by 42 inches square. The floor slab is a reinforced concrete flat slab, 6 inches thick with No. 3 and No. 4 bars.

The existing concrete slab is in satisfactory condition, although some tension cracks can be seen.

IV. Subsurface Soil Condition

Two 8 inch diameter test holes were drilled to a depth of 101.5 ft. through the existing floor slab using a failing 1500 drill rig. The first 10 to 13 ft. were drilled using flight auger. The remainder

of the test holes were drilled by the wash boring method. Based on soil borings, several different types of soil layers were encountered. The soil beneath the slab has settled and separated from the slab, leaving a void 2 to 3 inches. One of the borings revealed a 2 ft. layer of debris 8 inches below the concrete surface consisting primarily of rotting wood.

V. Discussion

The Pile driving records, shown on Bureau of Yards and Docks Drawings Nos. 402099 thru 402103, of 2 May 1941, indicated the bearing capacities of the piles were determined by the following pile driving formula:

$$Q = \frac{2WH}{S+0.3},$$

Where Q= Bearing capacity (lbs.), W= Weight of striking portion of hammer (lbs.), H= Height of fall of hammer (ft), S= penetration of last 3 blows of hammer (in.). Single-acting steam weighing 5000 lbs and 6500 lbs were used to drive the piles. Applying this information and additional information shown on the drawings, the pile driving formula shows that the bearing capacity of each pile is approximately 30 tons.

Using the results of the field investigation, primarily the core sample boring logs, penetromoter test results, and applying the parameters for a stiff cohesive soil, a ultimate bearing capacity for each pile was calculated in accordance with the ultimate load capacity formula in NAVFAC DM-7. Dividing the ultimate bearing capacity of each pile by a safety factor of 2 yields an allowable bearing capacity of 40 tons per pile.

Using the As-built drawings, shown on Bureau of Yards and Docks Drawings No. 151585 thru 151625, of 17 Dec 1940, a structural analysis was made to determine an allowable live load for the existing concrete slab. The existing slab and piles were designed for a 500 pound per square foot of live load and 30 tons of bearing capacity, respectively.

VI. Recommendations

1. Further examinations should be made as follows:

A. Additional test holes are needed to further substantiate the conditions found in the initial test holes. Debris, consisting of rotting wood, and a layer of saturated, silty sand were encountered

in one hole only. Until further information is obtained it must be assumed that this generalized condition exists throughout the entire floor area.

B. Slab should be cut to expose the existing piles so that their type, size and present condition can be examined and evaluated.

2. The floor slab should be removed and a new one placed as follows:

A. New piles will be added between existing piles so the piles will be 5 feet on center each way. (See sketch 2)

B. Remove existing concrete slab and pile caps in area and provide grade beams on piles and 8" concrete slab. (See sketches 1 & 2)

C. The proposed storage system in Bldg. 422 should be installed in accordance with the local seismic regulations.

PRELIMINARY ENGINEERING COST ESTIMATE
PRINCIPAL CONSTRUCTION FEATURE(S)
NAVDOCKS 2493 (5-58)

STATION: NSC Oakland, CA

DATE: 23 Sept 1976

SUMMARY LINE ITEM DATA

CODE	LINE ITEM TITLE	EST. COST
	Engineering Study for Warehouse Floor in Building 422	
1030	ESTIMATED ARCHITECT AND ENGINEER FEE	
	TOTAL	

PRINCIPAL CONSTRUCTION FEATURE(S)

CODE	ACF	DESCRIPTION	UNIT	QUANTITIES	ENGINEERING ESTIMATES		BUDGET ESTIMATES		FEATURE BUDGET	
					UNIT COST	COST	UNIT COST	COST	UNIT COST	COST
		General requirements	LS			70,000				
		Cut & remove exist 6" conc. slab(90' x 600')	CY	1,000	3.88	3,880				
		Remove exist pile caps (3'-6" SQ x 13"thick)	EA	531	12.25	6,500				
		Excavate 12" soil & recompact subsoil	CY	2000	4.82	9,640				
		Auger 18"dia x 15'-0" deep (for piles)	EA	1,611	25.00	40,300				
		Presstressed 30 ton conc. piles(12"SQ x 40'long)	EA	1,611	440.00	708,800				
	C	NON-TECHNICAL COLLATERAL	LS	LS	LS		LS		LS	
	T	TECHNICAL COLLATERAL	LS	LS	LS		LS		LS	
2000		SUPPORTING CONSTRUCTION FEATURES	LS	LS	LS		LS		LS	
								LINE ITEM TOTAL		

PRELIMINARY ENGINEERING COST ESTIMATE
PRINCIPAL CONSTRUCTION FEATURE(S)
NAVDOCKS 2493 (5-58)

STATION	DATE	
NSC Oakland, CA	23 Sept 1976	Sheet 2 of 2

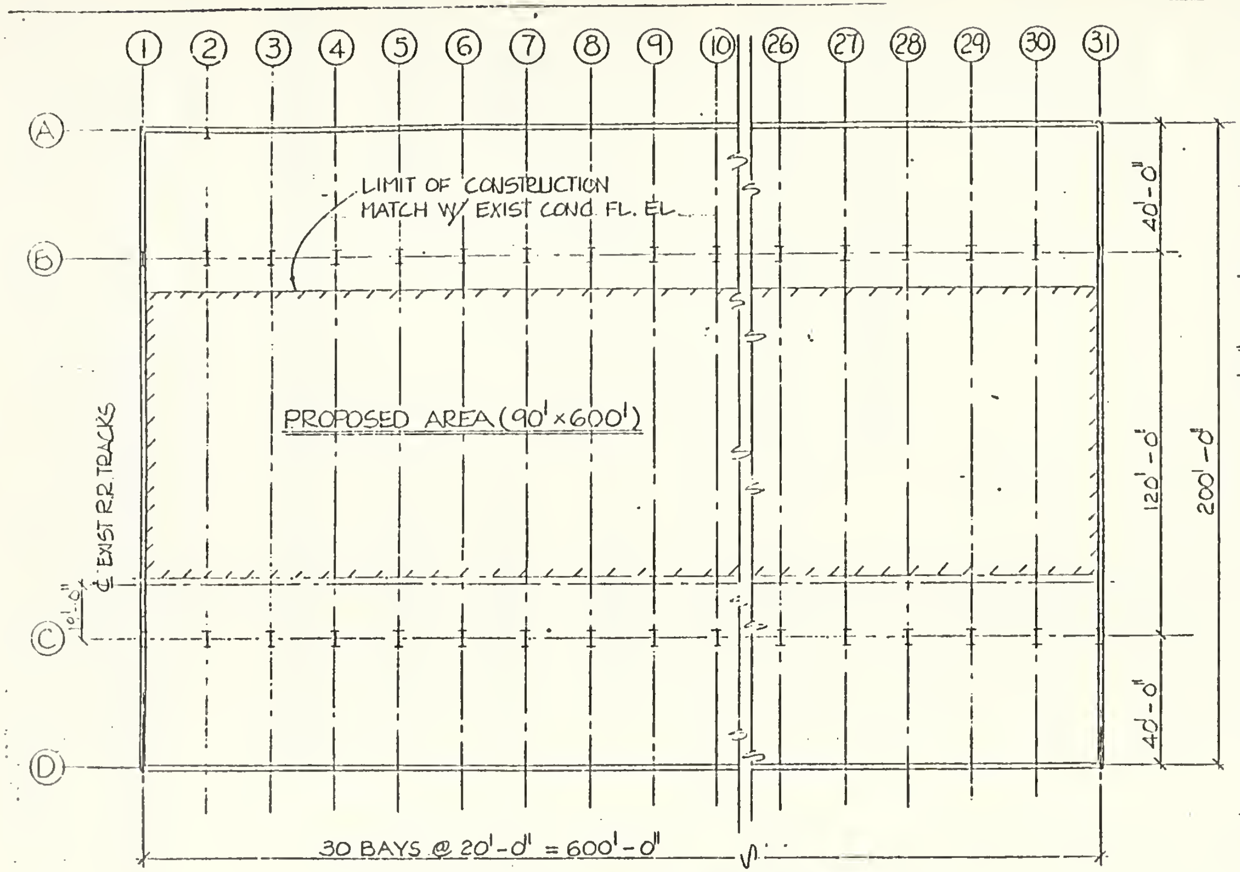
SUMMARY LINE ITEM DATA

CODE	LINE ITEM TITLE	EST. COST
	Engineering Study for Warehouse Floor in Building 422	
1000	ESTIMATED ARCHITECT AND ENGINEER FEE	
	TOTAL	

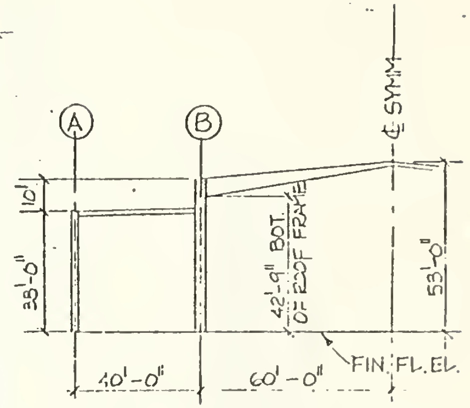
PRINCIPAL CONSTRUCTION FEATURE(S)

CODE	ACF	DESCRIPTION	UNIT	QUANTITIES	ENGINEERING ESTIMATES UNIT COST	ENGINEERING ESTIMATES COST	BUDGET ESTIMATES UNIT COST	BUDGET ESTIMATES COST	FEATURE BUDGET UNIT COST	FEATURE BUDGET COST
		Dowels @ 12" o.c. between exist & new conc. slab	EA	1,380	22.40	30,900				
		Reinforcing bars in place	LB	521,800	0.28	146,100				
		Grade beam forms left in place	EA	2,160	11.20	24,200				
		Conc. in place for grade beams & 8" slab	CY	2,840	40.32	114,500				
		Conc. finish	SF	54,000	0.41	22,140				
						1,176,960				
					Say	1,200,000				
		10% contingency, 6% SIOH & Engineering Cost are not included.								
	C	NON-TECHNICAL COLLATERAL	LS	LS	LS		LS		LS	
	T	TECHNICAL COLLATERAL	LS	LS	LS		LS		LS	
2000		SUPPORTING CONSTRUCTION FEATURES	LS	LS	LS		LS		LS	
								LINE ITEM TOTAL		

5



EXIST. FLOOR PLAN - BLDG. 422
1" = 40'-0"



TYP. TRANSVERSE SECTION
1" = 40'-0"

DESIGN CRITERIA

1. FLOOR LIVE LOAD --- 1800 PSF
2. SEISMIC --- ZONE 4.
3. CONCRETE --- F'_c = 3000 PSI
4. REINF. STEEL --- F_y = 60 KSI
5. PILES --- PRESTRESSED CONC. 30 TONS CAPACITY

SKETCH 1.

APPENDIX H.

EQUIPMENT SYSTEM COSTS

	Purchase Price[1]		Hourly Operating Cost*
Counterbalance Forklift Truck	16 K		$1.77
Reach Truck	21.4 K		$2.08
Side Reach Truck	25.7 K		$2.33
Sideloader Truck	49.3 K		$3.67
Turret Truck	64.2 K		$4.53
Stacker Crane - 40'	70 K		$10,000/year
Stock Picking Vehicle complete with battery charger	78 K		$5.31
Transfer Car for Stacker Crane	30 K		$4,500/year
RACKS			
Conventional Racks up to 40' - no machine guidance involved	$30/opening[2]	or	$3.21 pallet/year
Conventional Racks up to 40' - machine guidance involved (Stock Picker)	$60/opening[3]	or	$5.95 pallet/year
ASRS Racks up to 40', up to 2600# load	$100/opening[4]	or	$10.00 pallet/year

[1]Prices taken from NAVSUP Pub 529, updated by 10% to 1977 prices and verified by contracting manufacturers.

[2]Verified by MHE, October 1976, page 80.

[3]Verified by Navy Concept Study for Second Increment Cold Storage Warehouse at NSC Norfolk (MCON P-843), dated 12 October 1976.

[4]Verified by contacting two contractors (Conco and Demag) and obtaining quotes based on 40 foot high system.

*Based on estimated purchase price of equipment averaged over a 10 year life, assuming straight-line cost recovery, $1500/year maintenance and operating costs and 1750 hours/year of operating time. Stacker crane - $3000/year maintenance and operating costs.

EQUIPMENT SYSTEM COSTS (cont.)

	Purchase Price	Hourly Operating Cost
GUIDANCE SYSTEMS		
Floor mounted rack for S/R machines	$45/ft. installed.	
Wire buried in floor	$ 6/ft. installed.	
Logisticon buried wire control unit for MHE	$6900/unit	

APPENDIX I.

TABLE OF STANDARD TRANSACTION TIMES

FOR PALLET HANDLING SYSTEMS[1]

SYSTEM	STORAGE LEVELS	TRANSACTION TIME (MINUTES/TRANSACTION)
Counterbalanced Truck	2	1.67
	3	1.82
	4	2.00
Reach Truck	2	1.63
	3	1.79
	4	1.97
Side Reach Truck	2	1.48
	3	1.64
	4	1.82
Sideloader Truck	2	1.38
	3	1.53
	4	1.65
	5	1.79
	6	1.91
Turret Truck	3	1.41
	4	1.49
	5	1.59
	6	1.70
	7	1.83
Stacker Cranes	5	1.29*
	6	1.29*
	7	1.29*

Note: Transaction times are computed as a combination of a standard travel distance, turning movements of the vehicle, starts and stops of the vehicle, an allowance for paperwork for each transaction, time required to store the load and a composite time value for accessing, lifting and lowering the load. In captive vehicle systems, this represents machine cycle time.

[1]NAVSUP Pub 529, page 19-13.

*No difference occurs because vertical travel time is less than horizontal travel time. All vertical movement will be accomplished during horizontal travel. This standard represents a machine cycle and is not a Labor dependent picking time. Labor costs are based on the amount of time required to enter information into the system, in this case .30 minutes/transaction.

APPENDIX J.

SPACE REQUIREMENTS FOR VARIOUS SYSTEMS PER 1000 PALLET OPENINGS - SQUARE FEET[1]

System	Number of Storage Levels 2	3	4	5	6	7
Counterbalance Truck	30500	20300	15250			
Reach Truck	22300	15000	11200			
Side Reach Truck	17700	11800	8800			
Sideloader Truck (Guided Aisle)	19300	12900	9600	7700	6400	
Turret Truck (Guided Aisle)		11300	8500	6800	5700	4900
Stacker Crane				6200	5170	4420

[1] NAVSUP Pub. 529 Pgs. 16-18, 16-8, 16-28, 16-38, 16-48, 16-60.

APPENDIX K.

AREA PER PALLET STACK

SQUARE FEET[1]

SYSTEM	SQUARE FEET
Counterbalanced Truck	61.0
Reach Truck	45.0
Side-Reach Truck	35.3
Sideloader Truck	38.6
Turret Truck	34.0
Stacker Crane	31.0

[1]NAVSUP Pub. 529, pps. 16-6, 16-16, 16-26, 16-36, 16-46,16-56.

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